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14 October 1960
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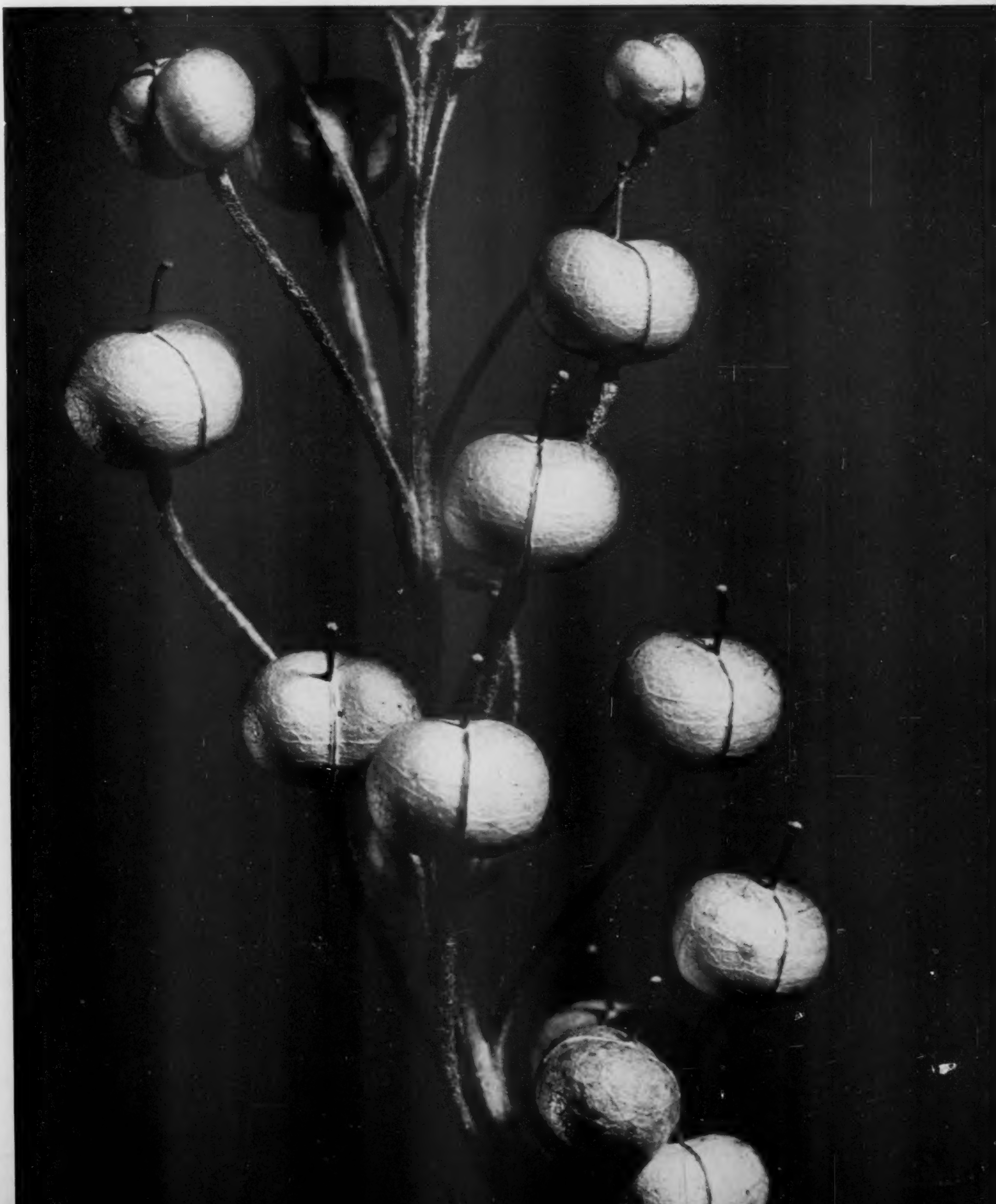

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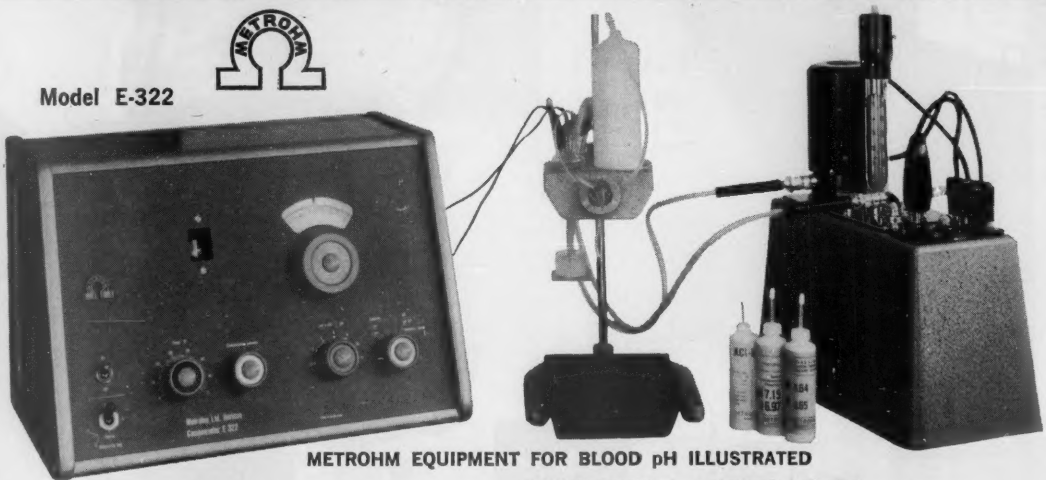

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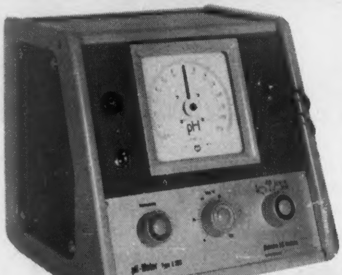

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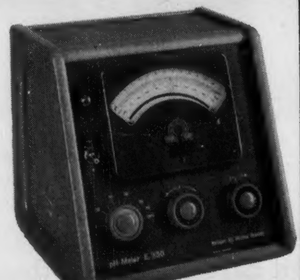

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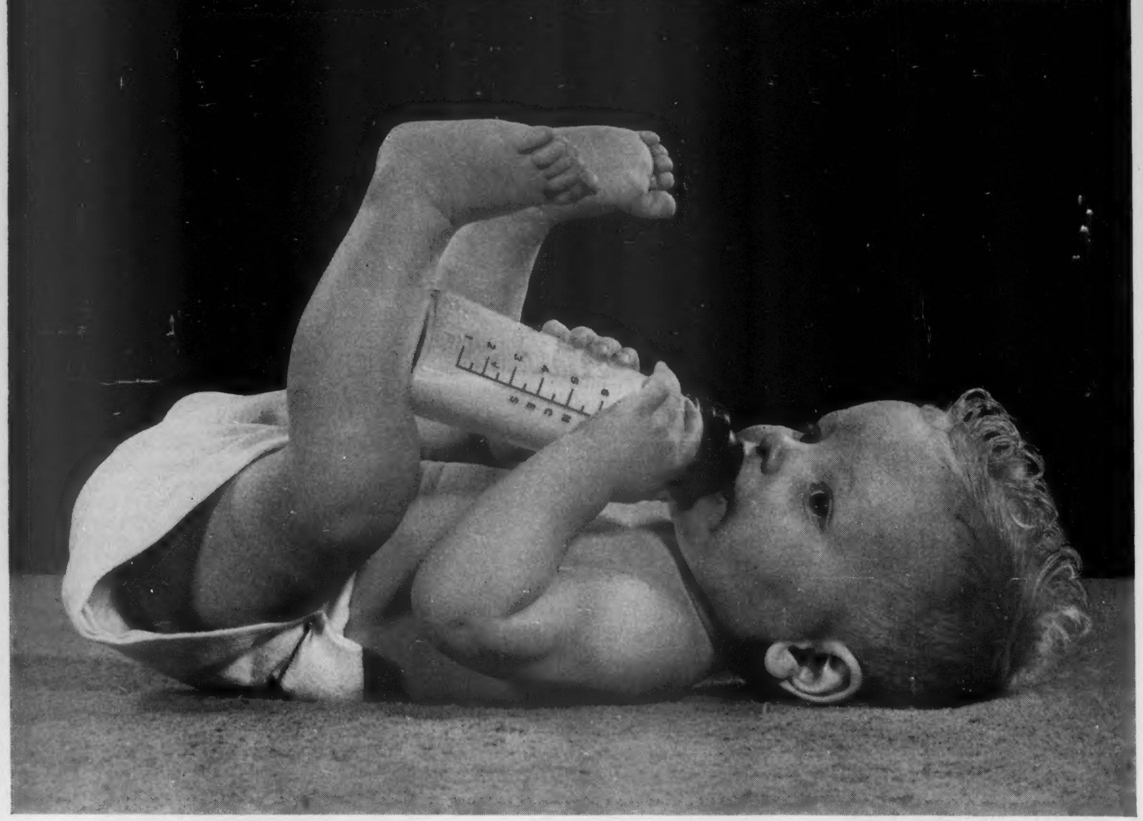

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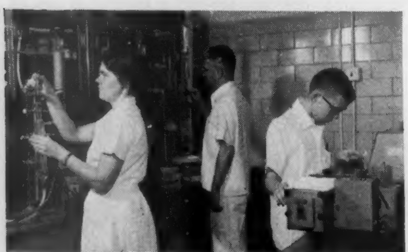

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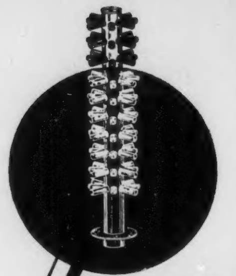

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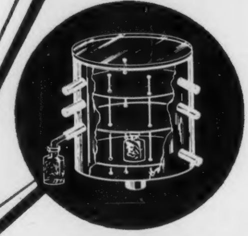

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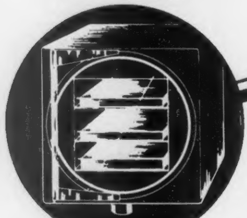

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Research with Human Subjects

It is the nature of scientific inquiry to push towards the limits of the phenomena being studied, and the limits of research on human behavior will surely entail some danger to the subjects. As a current example, what kinds of performance can be expected of an astronaut in the super-solitary confinement of space? Under what circumstances will integrated, rational behavior break down? Such questions can be answered only by putting experimental subjects under real stress, and the subjects who volunteer to help find the answers, even under simulated and earth-bound conditions, are running some risk of personal damage. So are subjects in studies of other types of stress, fatigue, or the factors that induce abnormal mental states.

Most discussions of the legal and moral problems of the use of human subjects have been written from the medical point of view. Medicine has the most experience with human subjects, but in several respects the medical experience provides a quite inadequate guide. In testing a new medical or surgical technique on human patients it is customary to explain the nature of the technique, its possible dangers, and its possible beneficial results, and to secure the patient's consent before the new technique is tried. In psychological research, neither explanation nor consent can be so easily handled. Explanation of the nature or prospective results of a psychological experiment may vitiate the results. And if the experiment cannot be fully and honestly explained, to what has the subject consented? Or has he in fact consented at all?

There is another difference. A new medicine or operative technique is ordinarily tried out on ill patients who may themselves be directly benefited. In contrast, research of the type being considered must frequently be carried out on normal and healthy subjects who may never directly benefit from the experiment. Clearly the differences are too great to allow using the precedents of the physician-patient relationship as a total guide in handling the problems of the experimenter-subject relationship.

In a thoughtful analysis of this issue, the *Duke Law Journal* (No. 2, 1960) recently offered a partial solution with the concept of "liability without fault." Under this concept, if a subject is damaged as a result of participation in a psychological experiment he would be entitled to be made whole, through treatment or rehabilitation, or to receive compensatory damages. Thus the subject would be protected. The experimenter would also be protected. He would not be considered to be at fault, but rather to have been acting in the interest of society. Thus society, through appropriate government channels, would assume the costs of rehabilitation or compensation just as society, also through government channels, supports most of the experimentation for which the concept of liability without fault would be appropriate.

Some practical problems remain, such as which experimenters would be protected and how psychological damage would be assessed. But the fact that such details and the underlying legal and moral issues are being seriously considered constitutes somber evidence that scientific inquiry will prove increasingly powerful in gaining knowledge of man himself.—D.W.

14 October 1960, Volume 132, Number 3433 **SCIENCE**

Sterilization of Interplanetary Vehicles

Earthly organisms can be kept from contaminating the moon and planets, but careful planning will be required.

Charles R. Phillips and Robert K. Hoffman

For the past several years, biologists have been expressing their increasing concern that man, as he proceeds in his race toward outer space, may unwittingly be propagating biological contamination. An international committee, the Committee on Contamination by Extraterrestrial Exploration (CETEX), has formally recommended (*1*) that all efforts be made to prevent any such contamination of the moon or other celestial bodies. Lederberg and Cowie (*2*), Davies and Communtzis (*3*), Sagan (*4*), and Lederberg (*5*) have published on this subject in detail. The reasons proposed for this concern have not all been the same, and speculation has been varied as to what evidences of exobiology or nonterrestrial life might be expected on the moon or the planets and how contamination might affect such life, if any exists. There is complete agreement in these articles, however, that the spreading of biological contamination or pollution should be avoided most carefully until we have conducted careful biological studies on these extraterrestrial bodies. Now that the first physical contact has been made with the moon and since there is a probability that such contacts will become increasingly frequent, specific plans for implementing these recommendations are required, if this caution is to be observed.

In this country the National Aeronautics and Space Administration is actively investigating means of preventing extraterrestrial biological contamination. In this undertaking it has enlisted the cooperation of the U.S. Army Chemical Corps, through a government interagency agreement, because of the Chemical Corps' considerable success in developing techniques for the sterilization of unusual objects ranging from delicate laboratory equipment to rugged 6 by 6 Army trucks. The Russian Government, apparently, is similarly concerned. It was announced over Radio Moscow that the probe which the Russians landed on the moon just prior to Khrushchev's visit to this country had been sterilized.

Three questions should justifiably be asked concerning the biologists' contention that no living organisms should be transported to the moon or the planets, and that even nonliving organic matter so transferred be minimal. First, why should objects launched from earth which might hit the moon or one of the planets be free of terrestrial life forms? Second, granted that they should be, would not all life forms be automatically killed in passage because of the rigors of interplanetary space? Third, if the answers to the first and second questions indicate that all objects which may intercept extraterrestrial bodies should be sterile prior to launching, can this sterilization be accomplished without adding crippling restrictions to the space exploration program? The answers to these three questions require some discussion.

Why Contamination Must Be Avoided

The first question which concerns the desirability of avoiding accidental contamination of extraterrestrial bodies with terrestrial forms of life, is intimately related to an unsolved scientific question of fundamental importance, that of the origin of life itself. According to the old but now more or less discredited panspermia hypothesis of Arrhenius, spores of living organisms drifted through space and seeded suitable planets upon which they came to rest. Most present-day biologists believe, however, that life might arise independently on any world where suitable physical conditions have existed for a sufficiently long time. Resolution of these divergent views requires evidence of a sort that might well be provided by the moon and the planets, as long as their present biology remains unaltered until it can be investigated.

By many, for example, the moon has been thought to have existed for several billion years as an airless, barren body with no biology of its own, but capable of sweeping up the debris of outer space and preserving it in its nooks and crannies, whence it can be recovered and examined to see if any of this interstellar material shows evidence of organic origin. Sagan and Firsoff, on the other hand, contend that simple organic compounds or even life may have arisen on the moon (*4*, *6*). Whatever may be the true situation, if the moon's surface becomes contaminated with living microorganisms from earth, or even with considerable amounts of organic debris from earth, before the "moondust" (*2*)

The authors are staff members of the Physical Defense Division, U.S. Army Chemical Corps Biological Laboratories, Fort Detrick, Md. Dr. Phillips is chief of the Division.

has been examined, a priceless opportunity to assess these possibilities may be lost. If all microorganisms or biological material carried to the moon were to remain within a limited area around the point of impact, this danger of contamination would be of less concern, for impact areas could then be easily identified and avoided in biological studies. Unfortunately, however, this would probably not be the case. Because the moon is almost totally lacking in atmosphere, particles ejected by a hard landing would encounter too little frictional resistance for their velocity to be appreciably diminished. Hence, even particles as small as bacteria might be expected to land anywhere on the moon's surface, even on the far side, depending upon their initial trajectory.

With Mars, and possibly with Venus, the concern over possible contamination is even greater. To the best of present knowledge, terrestrial microorganisms might not only survive on these planets but might find nutrient, thrive, and multiply. Indeed, bacteria did multiply when introduced into chambers that reproduced the conditions believed to prevail on Mars (*7*). Furthermore, spectroscopic evidence and seasonal color changes on Mars lead scientists to believe that some form of life, possibly similar to low forms of terrestrial vegetation, already exists there. If so, man may soon for the first time be able to examine in their native habitat life forms other than those which arose on earth. Extreme caution is needed, however, to ensure that Martian life, if it does exist, is not destroyed or irreversibly changed before it has been studied.

Just over 100 years ago Darwin pointed out the constant struggle for the survival of the fittest which goes on between all life forms occupying the same environment. The perilous knife-edge balance maintained by such competing forms is never more evident than when a new form is suddenly introduced and a new balance must be attained. The results of the transfer of rabbits from Europe to Australia and of Japanese beetles from their homeland to the eastern seaboard of the United States are well-known examples. Another example is the unrelenting effort of crab grass to invade and overwhelm the bluegrass of American lawns. It has been stated (*3*) that, to prevent the possibility of any such biological accident, no probe that allows as much as a one-in-a-million chance of landing a viable organism on the planetary surfaces should be launched toward either Mars or Venus. It has also been pointed out (*5*) that if it is possible for earthly life to infect neighboring planets, the reverse is also true, and that here much more is at stake than the loss of an unparalleled opportunity for scientific investigation. In the not too distant future, interplanetary quarantine regulations may become even more necessary than present national and regional regulations.

The first of the three questions posed above has thus been simply answered. All earthly forms of life must be kept away from nearby celestial bodies to avoid jeopardizing, if not altogether losing, the unique chance to gather reliable data on possible extraterrestrial life. Nothing that will be done in the next decade or so, with the possible exception of creating from fuel exhausts a trace atmosphere on the moon, could permanently affect these bodies in any way except biologically. Even if, for example, good measurements of the gravitational field of the moon are not obtained this year or next, this force will remain unchanged a decade (or a century) hence, no matter how many probes have landed meanwhile on its surface. We have no such assurance concerning the biology of these bodies. Their biology, and indeed the biology of the earth as well, may be changed irreparably, and in a comparatively few years, unless unusual caution is exercised.

Resistance of Life Forms in Space

If one grants that it is desirable to prevent contamination, the second question then needs to be answered. Won't the sterility required be automatically achieved by passage of the vehicle through interplanetary space? This is by no means certain. The conditions believed to exist in outer space were recently discussed by Newell (*8*). In the 1958 Leeuwenhoek Lecture before the Royal Society, Keilin (*9*) carefully reviewed the resistance of various life forms to harsh environmental conditions when in a state of suspended animation, or kryptobiosis, to use the term he coined. A comparison of the information in these two documents can lead only to the conclusion, which has been presented before in considerably more detail (*3*), that spores or other earth life forms could indeed survive such a journey. Briefly, the penetrating radiations of outer space are not of sufficient intensity to assure sterility. The ultraviolet radiation is intense enough, but so easily shielded that only organisms uncovered on the surface of the space vehicle would be exposed. Cold, even down to a slight fraction of a degree above absolute zero, has no lethal effect (*8, 10*). Heat is lethal, even if the resistance of organisms in an evacuated dehydrated state is greater than we have supposed (*11*), but the temperature within space vehicles is carefully controlled at more or less room temperature so that the instruments will perform satisfactorily. This temperature can be maintained with remarkable accuracy merely by having the surface of the vehicle contain a predetermined ratio of reflecting and absorbing areas.

Vacuum has no deleterious effect on microorganisms, at least as far as it has been measured, although admittedly experiments with extremely high vacuum, paralleling those of Becquerel (*10*) with extremely low temperatures, have not been performed. As for the hazards in landing on an extraterrestrial body, the momentary heat and pressure of a high-velocity landing on a hard surface should not exceed the levels achieved for brief fractions of a second in explosions, which bacteria have survived, nor would the atmosphere of Mars or Venus necessarily consume a space vehicle coming in at high speed, as micrometeorites are heated and consumed in the earth's atmosphere. In short, only by sterilizing space vehicles before they leave the earth can it be assured that living earth forms will not be transported to other celestial bodies.

Sterilization Techniques

The third question now requires an answer. Are relatively simple techniques available whereby space vehicles may be sterilized? The answer appears to be yes. Heat, radiation, and chemical sterilization techniques in various modifications are of proved efficiency. The choice of the method for space vehicles is governed by two considerations: (i) when and where must the treatment be applied, and (ii) will the treatment damage any part of the vehicle? It will be seen that although all of these sterilizing techniques in one form or another may be used on individual components, the final treatment given the fully assembled vehicle will, almost of necessity, be chemical, with the sterilizing agent in the gaseous state.

One of the first considerations which leads to this conclusion is the dual aspect of the sterilization problem. Not only must the vehicle be sterilized but it must be kept sterile until it has left the earth's atmosphere and started on its lonely journey through space. The second half of this problem could well be the more difficult technically. After the final treatment the vehicle must not be touched, handled, or moved unless completely sterile technique is observed in these manipulations; otherwise it becomes recontaminated. Sterile handling techniques have of necessity been evolved, as in hospital surgery for example, but at best they are extremely tedious, and even with well-trained personnel, accidental breaks in sterile technique often occur. The difficulties involved in sterile handling can be largely avoided if the final sterilization treatment is given at the last possible moment before launching, after the vehicle has been placed into position and thoroughly tested. This implies a treatment which can, if necessary, be carried out in the cramped quarters atop a launching gantry. It would be difficult indeed to place the necessary amount of cobalt-60, for example, with its accompanying shielding material, in such a location that the assembled payload would receive a sterilizing dose of gamma radiation. Applying sufficient heat to sterilize the payload in such a position would also be almost prohibitively complicated. Moreover, if any single component of the space vehicle could not withstand the necessary amount of heat or radiation, it would be impossible to shield that component while treating the rest of the payload. Chemical sterilization with ethylene oxide gas, however, can be applied almost as conveniently at 120 feet in the air as at ground level. Fewer types of materials are damaged by this technique than by any other known sterilization method (*12*). If some component should prove to be sensitive to ethylene oxide, moreover, it could be sterilized prior to assembly, by another technique, and shielded from subsequent ethylene oxide exposure simply by building a gas-tight barrier around it. Anything incased in metal or certain plastics would be protected.

Although ethylene oxide sterilization is a relatively new development, there have been an increasing number of new applications of this technique within the past decade. The method is slow, requiring up to six hours' exposure time, but it is effective with many types of materials and objects that would be hopelessly damaged by other methods of sterilization. The gas diffuses readily through many types of porous materials but cannot, of course, penetrate hermetically sealed areas. When mixed in proper proportions with fluorinated hydrocarbons, the product is nonflammable (*13*) and can be packaged in convenient light-weight metal cans. Although elaborate automatic ethylene oxide sterilizing equipment is now available commercially, particularly for hospital use, the method can be adapted for use in extremely simple exposure chambers; for example, a simple polyethylene bag tightly closed at the neck serves adequately as a device to contain the gas (*14*). Within such a plastic container, sterilization is achieved at ambient temperatures and relative humidities, and at essentially ambient pressures, since the bag can expand as the liquefied chemicals volatilize. The same technique can be used to sterilize objects of any size or shape by building about them a bag or tent of heat-sealed plastic sheeting and admitting the sterilizing mixture into this container. At concentrations of about 300 to 400 milligrams of ethylene oxide per liter of air and at room temperature, sterilization will occur in six hours or less (*14*).

The question of how and where to place the plastic covering could well be answered separately for each space vehicle, since no two are likely to be identical in design. How the cover is to be removed before launching and how the space vehicle will be kept sterile once the cover has been removed must also be considered. In many cases, sterilization of other items, not just of the space vehicle itself, must be considered. For example, if the design is such that the last rocket stage will follow the space vehicle rather than return to earth or be shunted off elsewhere into space, it too must be sterilized. Perhaps it might be best to consider one typical example and discuss in general terms how the procedure might work in this case.

A Hypothetical Case

Such a typical example might be a space vehicle atop a third-stage rocket, with both of them covered by a nose cone or fairing. The chief function of the fairing is to furnish environmental protection on the ground and, more particularly, during flight through the earth's lower atmosphere. The fairing in this assumed case would open and fall back to earth after the vehicle had reached a height (200,000 feet, for example) at which air pressure would be too low to damage the vehicle passing through it at high velocity. The third stage, we can assume, would separate from the space vehicle but would follow it throughout its flight and would be expected to impact any body upon which the vehicle itself might land. In such a hypothetical case, a sheet of plastic large enough to extend out beyond the fairing could be placed underneath the third-stage rocket during assembly. When the final check had been made on the assembly, a complete covering could be made by sealing other sheets of plastic to this base sheet, enveloping the third stage, vehicle, and fairing. Ethylene oxide gas would be admitted into this inclosure and, since the fairing would not present a hermetically sealed barrier, the gas would sterilize the space vehicle and the third stage as well as the fairing itself. After six hours' exposure, the plastic sheet could be cut away and removed, and the ethylene oxide gas would be dissipated in a matter of minutes. Before launching, the outside of the fairing would almost certainly become recontaminated, but it would act essentially as a petri dish cover does, preventing airborne organisms from entering underneath it and recontaminating the space vehicle or the third stage. To keep objects cool while the vehicle is still on the ground, conditioned air is sometimes blown under the fairing. This air can be kept sterile by the simple process of passing it through bacteria-tight filtering material, such as cotton, asbestos, or spun-glass fibers. Filters of the necessary efficiency are readily available. Upon launching, when the vehicle would be rising through the lower atmosphere, the fairing would protect the sensitive components of the payload against the heat and mechanical effects of atmospheric friction. With proper design, the fairing would continue to furnish biological protection in flight as well as on the ground, again acting like a petri dish cover. The sterile air under the fairing would diffuse outward as the atmosphere became less and less dense, and nonsterile outside air should not contact the probe. When the fairing was discharged, at the outer fringes of the atmosphere, the probe would be high enough in the air so that unshielded ultraviolet rays from the sun would prevent surface contamination from then on, if any microorganisms exist that high.

It was mentioned above that if the last-stage rocket or other equipment was also expected to impact on the lunar or planetary surfaces, these sections as well as the payload itself should be sterilized. Some preliminary calculations have indicated, however, that an extremely simple sterilization technique might be available for such material, which is required to function only during take-off and which is essentially inert thereafter. It was also stated above that temperature within the space vehicle itself could be carefully regulated by controlling the relative amounts of absorbing and reflecting areas on the surface. If the odd bits of metal that are not required to perform except during take-off had surfaces which were entirely adsorptive—that is, surfaces that were painted black—they might well, at rates dependent upon their particular geometry, slowly become hot enough in outer space so that they would be sterile before impact.

Once the decision has been made to perform the final sterilization with ethylene oxide at the last possible moment before launching the probe, one can proceed backward and design a probe suited to the ethylene oxide treatment, just as one designs the probe to withstand the forces of acceleration or vibration to which it will be exposed during launching.

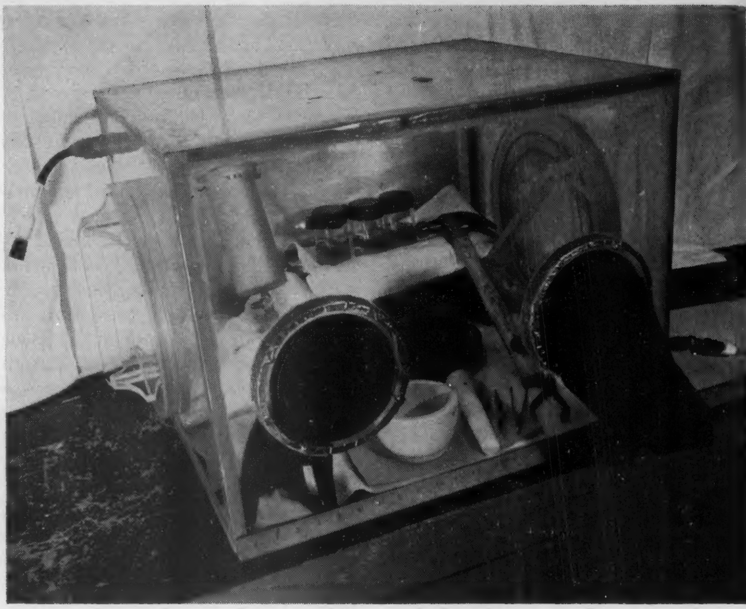

Fig. 1. Exposure chamber inside which electronic components are sterilized externally and then broken open so that they can be tested for internal bacterial contamination. A sterile hammer, anvil, pliers, and mortar and pestle may be seen, as well as the taped broth blanks into which the pieces from the components are placed. The empty ethylene oxide container is at the rear of the chamber, at left. The components to be tested are hidden behind the rubber gloves.

Design Considerations

Two design considerations are involved in constructing a probe to be sterilized with ethylene oxide. First, the design engineers should test all the materials, such as paint and adhesives, that will be used in construction, to satisfy themselves that the treatment will cause no damage. Secondly, the designer should see to it that the vehicle contains no hermetically sealed areas—areas that cannot be reached by the gas—unless the interior of such areas has been sterilized before sealing or can be sterilized by other techniques after sealing. Once any such component is sealed, the interior cannot be recontaminated, since bacteria cannot enter any space inaccessible to the gas. There is no concern about external recontamination, for this will be taken care of in the terminal sterilization process.

For example, welded aluminum tubing may be used as the basic framework for a space vehicle. Once this tubing has been welded together, no gas can penetrate the interior. The design engineer in this case would have two simple ways of making sure that microorganisms would not be transported inside this framework. He might bore a series of small holes in the framework, which would allow the sterilizing gas to enter, without reducing the strength of the framework. Or, more simply, he could easily heat the framework in an oven to sterilizing temperatures before he attached any heat-sensitive material to it.

This concern over possible contamination in hermetically sealed areas is based on the consideration that in a crash landing on a hard surface, the space vehicle might shatter completely. Any organisms that might be present in such inaccessible locations would be released. Bacteria might survive such a crash landing far better than metal or plastic objects. Thus, the requirement is not only that all accessible surfaces of the object should be sterile but that no viable organisms should be entrapped within the object which would be released if it were broken apart. Examples other than welded tubing of components in which organisms might be entrapped beyond the reach of a sterilizing gas are individual electronic components, assemblies of electronic components that have been encased or potted in plastic, tight metal-to-metal surfaces (particularly those held together with a sealing mastic), and aluminum or plastic honeycomb sheets.

Exploratory Experiments

Certain practical experiments have recently been conducted at Fort Detrick to gain information on problems such as these. The theory behind such studies is that, although each space vehicle may well be distinctly different from all others, it will of necessity be constructed from a limited number of components and materials. These components can be studied separately, to see if they already carry within them living microorganisms as received from the manufacturer, or if assembly techniques will further entrap living microorganisms. The practical experiments along these lines have been, to date, largely exploratory. They are reported here merely to show how the problem of designing a space vehicle which will be sterile internally and externally is being attacked.

The experiments were performed in a sterile environment inside an airtight, transparent plastic chamber (Fig. 1) whose inner contents and surfaces could be sterilized with ethylene oxide gas and then flushed with filtered sterile air. The equipment is very similar to that recently developed for conducting germ-free animal experiments (*15*) or for use as bacteriological safety cabinets (*16*). The cabinet is typical of the sealed plastic covering that will be utilized in the terminal sterilization treatment of the assembled space vehicle.

In all cases, ethylene oxide-fluorinated hydrocarbon mixtures were used at ambient temperatures and admitted into areas not previously evacuated, displacing air so that the operation was carried out unpressurized. Six hours' exposure was adequate to insure sterilization in such a cabinet. It should be pointed out that cabinets of this type could also be used for sterile handling and assembly of certain components, should it prove more advantageous, or even necessary, to sterilize certain individual components, assemble them in a sterile atmosphere, and then seal them in a unit, rather than to sterilize after assembly.

The first tests were concerned with various electronic components—primarily transistors, capacitors, resistors, transformers, diodes, and the like, all small sealed units. The question was whether these units were manufactured under conditions which permitted the entrapment of viable organisms in their inner areas, where ethylene oxide could not penetrate.

The test procedure involved placing inside the chamber the electronic components to be tested, together with sterile broth blanks, forceps, hammers, mortars and pestles, a metal hammering block, metal saws, pliers, and a can of ethylene oxide-fluorinated hydrocarbon mixture. The chamber was closed, and the ethylene oxide was released to sterilize the exterior of all the items and the atmosphere within the chamber. After a six-hour exposure of the chamber to ethylene oxide, air sterilized by filtration through a cotton filter was passed through the chamber for 16 hours to remove all ethylene oxide gas.

Table 1. Electronic components with internal contamination.

Type of component	No. contaminated: No. tested
Transistor	1/17
Capacitor	13/62
Resistor	6/41
Diode	0/2
Transformer	1/1

Two of each type of electronic component being investigated had been placed in the chamber. After the ethylene oxide treatment, one component from each pair was placed, whole, in a broth blank. These served as controls and indicated that the exterior surfaces had indeed been sterilized by the ethylene oxide treatment. The other component was then sawed, hammered, or otherwise broken open and ground up as much as possible, and the pieces were placed in another broth blank. These broth blanks were sealed, removed from the chamber, incubated for seven days, and then examined for cloudiness which might indicate bacterial growth. The bottles were then opened, and aliquots of the broth were streaked on agar to check further for bacterial growth. The broth of each cloudy blank was also examined microscopically to check for bacterial cells. Anaerobic bacteria could grow in the broth but would not grow on the agar surface. Thus, only a microscopic examination would confirm the presence of these bacteria.

Following this, each broth blank was seeded with approximately 100 cells of *Staphylococcus aureus*, and after incubation an aliquot of this broth was streaked on agar. This last step was taken to assure that the blank was still capable of supporting microbial growth even though no growth had occurred in it when the electronic component was added. Positive growth in this step indicated that the material of which the component was made was not bacteriostatic or bactericidal.

Typical results obtained in these exploratory tests are given in Table 1. As is evident, transistors as a general class are more likely to be sterile internally than are capacitors, although at least one nonsterile example was found in each class. Considerably more investigations of this type will be necessary before definitive answers can be given concerning the biological status of all types of electronic components. Such data are now being routinely collected. Also, the ability of these components to perform satisfactorily after they have received various types of sterilization treatment is under investigation.

After various electronic components have been assembled into an electronic device, they are often potted or imbedded in plastic to give the object greater mechanical strength. When metal-to-metal contacts are made, plastics are also often used to strengthen the bond. A mastic may be used about screw threads, for example. Investigations have shown that if certain dry microorganisms of a hardy type are incorporated in the plastic monomers, they are quite capable of surviving the polymerization process. When the hardened plastics were treated with ethylene oxide, the surfaces were sterile, but living microorganisms were recovered when the plastics were sawed or cracked open. How long these bacterial spores would survive imbedded in plastic is yet to be determined, but again the resistance of certain life forms to harsh treatment is well exemplified. It appears that incorporation of a small amount of disinfectant, such as paraformaldehyde, in the plastic base may solve this problem. But this again emphasizes that, although the answer to the third question posed is in the affirmative—space vehicles *can* be sterilized—it is affirmative only if attention is given to the sterilization requirement in all stages of design and construction.

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The Two Aspects of Science

Control over nature and understanding of nature must both be held in equal honor.

George Thomson

Science is already valued for what it can do to increase man's control over nature, and feared for what some of its consequences may be. Some would have us consider these consequences as the sole justification of science. This view, or something very like it, is the official attitude in Marxist countries, and there are many in this country and in the U.S.A. who would be horrified to be told they were Marxists but who without any explicit statement do in fact act and speak as if they thought the same. But this view is too limited, as I hope to persuade you in this address. There is a second aspect. It is this: Science aims at understanding the nature of things; in this it is at one with religion and philosophy. But its approach is the opposite. These last try to gain knowledge of the whole, in the one case by an awareness of the deity, intuitive or revealed, in the other by building with words a system of thought which can account for fundamentals. Science starts from the other end. It begins by studying details, often apparently trivial details but things which are queer and appeal to human curiosity—things like black rocks which attract iron or rubbed amber which makes chaff fly.

This has been more successful than one could have expected. It is a method difficult to defend a priori—it has often been made fun of. Swift ridiculed the philosophers of Laputa who studied how to make sunshine from cucumbers. But the method works.

Concepts

From the study of details such as these come *concepts*; these concepts, or some of them, show vitality and take charge, as characters in fiction are said by authors to do. They are the bases for hypotheses and "laws"; they are the things that get names—mass, energy, temperature, entropy, wavelength, charge, electrons, quantum numbers, to take some examples from my own subject.

Some do not survive: caloric, phlogiston. Others are deposed from their independence and become vassals of the more successful, as mass has of energy or valency of electronic structure.

But the successful concepts—or the best of them—are not concerned with details any more; they penetrate deep into the heart of things. Electrons, for example, are regarded as present in all ordinary matter, and in any attempt to explain the behavior of matter—physical, chemical, or ultimately biological—one is, if one goes deep enough, forced back onto them. At present they stand as a fundamental concept, but even if, as is quite possible, they ultimately come under some still more general idea, the concept of an electron will still be used, as mass is in mechanics.

It unifies our thoughts over a vast area of facts. Thus there is excellent reason to believe that the whole of chemistry is explicable in terms of electrons and the wave functions which describe their location. This is an enormous simplification of thought, even if the mathematics are too difficult to work out in most cases. It does not much matter, from this point of view, that test tubes are cheaper than electronic computers, if you really want to know the answer to a practical question.

Scientific concepts enable certain aspects of the enormous complexity of the world to be handled by men's minds. They are suggested mostly by experiment but partly by mathematics, and controlled by the need that they should not lead to illogical consequences.

These concepts represent an extension of the human intelligence. They are not easy, many have subtleties which, for example, oblige the popularizer to take anxious care lest in trying to simplify he make statements which are simply untrue. Some are more fundamental than others, but even those which turn out to be only rough pictures of what really happens often retain their usefulness. They are sketches as compared with finished pictures, and if details are not needed a sketch is often clearer.

Concepts are discoveries as well as—indeed more than—inventions. They have more in common with the discovery of America than with the invention of the spinning jenny or of the electronic computer. Some, at least, have been forced on unwilling minds by hard facts and have resisted many attempts to displace them. I am thinking more especially of the quantum theory.

Not merely are they an exercise of the human mind which equals the brilliance of any system of thought, philosophical or even mathematical, but they represent reality.

The mature of the relationship is to me a mystery, but they are certainly not merely the product of the human mind.

Science is a pyramid based on many varied facts, topped with a crown of ideas reaching to the skies. These are its fruit, but they can change without affecting its stability. I sometimes think that in philosophy the pyramid is the other way up!

What we want as scientists—I am sure in this I speak for the great majority—is that the world should realize that we are not interested merely in making possible new drugs, television sets, or weapons, though all these are important, but in enlarging the bounds of human knowledge.

The greatness of the human race is indeed many-sided. Thus in the world of art there is a difference between the ability to compose or interpret a great piece of music and that which writes a great novel or paints a great picture. Yet all are evidence of greatness and worthy of the name. Still more so is moral greatness. "There is one glory of the sun and another glory of the moon and another glory of the stars."

I have no desire to exalt our pro-

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fession unduly, but surely the ability to understand, even to a limited extent, the world around him is one of the powers of which man has good right to be proud. Indeed it seems to be the one which most divides him from the animals. The lark's song, the heroism of a plover luring an enemy away from her young, the cat who was seen to attack a grizzly in defense of her kittens—these, if taken at their face value, are notable even by human standards, but I am not aware (though I speak which great diffidence) of any creature which even appears to be trying to discover any general principles.

The chance of understanding things of fundamental and permanent importance is what makes the pursuit of science fascinating and worth while.

Technology and Principles

These two aspects of science do not in fact conflict. The best way to make advances in technology, whether on the medical or the engineering side, turns out to be to understand the principles. This is quite a recent discovery; indeed, it has probably only recently become true. It would not have been much use, for example, to man in the stone age, or even a few hundred years ago, to try to understand the principles of tanning with no basic knowledge of chemistry to guide him. He did better by trial and error. Even the steam engine was developed with little knowledge of the determining principles, though the best scientific minds of the day were much interested and the thought they gave it advanced science by discovering thermodynamics.

Electrical engineering was the first important activity to be developed from the start on scientific principles, and even here Edison did great things on a decidedly sketchy knowledge. But increasingly more discoveries are made in research laboratories and fewer by workmen on the bench. This is what one might expect. As fundamental principles get known it is possible to use their consequences intelligently. Often these consequences are too complicated to be calculated, but knowledge of the principles is an enormous help by showing in a general way what is likely to happen.

Then of course there are the modern technologies which derive directly from some important new basic discovery, such as electronics and nuclear energy.

This dependence of technology on pure science is now pretty generally recognized by industry. The more progressive industries maintain research laboratories which both make use of the basic discoveries made in the universities and elsewhere and contribute their own. These laboratories may be owned and operated by individual firms, or be cooperative efforts of an industry in the form of research associations substantially helped by government. There are black spots, of course—industries which spend too little on research or organize it badly—but broadly speaking the need is realized and reasonably well met.

Influence of Technology on Science

Pure science receives a great return for what it contributes to technology, and this in two ways, materially and in the realm of ideas. Consider first the material return; a modern physics laboratory could not work without instruments developed for technology and obtainable cheaply because industry needs them in large numbers. Take just two examples out of many. The use of high vacua—and how important this is—has been enormously facilitated by the needs, first, of the electric light industry and then of the manufacturers of radio tubes. Again, the complicated electronic devices which crowd every physics research laboratory would be impossible without the cheap components of all kinds manufactured originally for radio and now for television. For this return by industry I sometimes think we academic scientists are not as grateful as we ought to be.

The other influence of technology is more subtle but as important. As science advances, concepts tend to become more and more abstract, further from anything that can literally be touched or handled. To take a simple case, energy is more abstract than mass, which it replaces. In the higher flights of theoretical physics abstraction goes much further. Is there not a danger that one may lose touch with reality and end up by supposing that some elaborate piece of mathematics represents reality when it is only a creation of the mind, inspired indeed by physical reality but no more like it than is a modern picture? I think we are safe as long as the people who make these theories are reasonably close to those who use them, not merely in laboratories but in industry.

A theory which involves detailed consideration of the behavior of particles less than a millionth of a millionth of an inch across would have seemed to Swift too absurd to be even worth ridicule. Yet one cannot regard it as a pipe dream when it leads to the great reactors of Calder Hall or Chapelcross. To me, the most amazing thing about science, and the most surprising and exciting fact about our world, is this astonishing connection between highly abstruse theoretical ideas and the matter of fact, in this case the housewife boiling her kettle with power from nuclei. This surely adds an immense thrill to discovery. I have no sympathy with those who regard technology as intellectually a poor relation of science. To me science without technology is incomplete and inconclusive. Systems of philosophy come and go; some are perhaps true, but who can tell? But when conclusions deduced from precise experiments by mathematical theory lead to detailed predictions from which working machines can be designed, machines which without the theory no one would have thought of in a million years, then indeed one knows that one lives in a universe which is rational and that one has found the key to one of its rooms.

In speaking to you, as I am, to stress the importance of the idealistic—almost the spiritual—side of science, I am hoping that my words may reach others not here who are brought less closely into contact with it than are most of you.

Theories and the Intellectual Climate

May I remind you of a few of the ways in which scientific knowledge has influenced and is influencing thought and the intellectual climate of the world? First and most obvious is the idea of evolution—that things change consistently and pass through successive stages, whether they are mice or stars; that not only do living creatures, in particular, go through individual changes but that in the flow of generations changes come over the race, or over a part of it, and that these changes lead to profound differences like those which distinguish men from mollusks. In the year of the centenary of the *Origin of Species*, just past, you have heard the profound consequences of this idea described much better than I can describe them.

In the course of my life the quantum theory has produced a revolution in physics comparable with that produced in biology by Darwin. We have been forced, some of us very unwillingly, to believe that at bottom the laws of physics are not statements of what *must* happen but of the relative chances of a variety of alternatives; that the determinism of the planets, for example, occurs merely because planets are enormous on the atomic scale and their distance from the sun very large, and that the *Nautical Almanack* would be impossible if the solar system was reduced to the scale of a molecule. Certainty comes with a massive body, or if the bodies are small, one must have very many of them so that the laws of statistics can manufacture near certainty out of highly uncertain events, as they do in life insurance.

This makes quite a difference to the way one regards the world, and I think its consequences are still not realized by the average educated man, though it has been accepted by the majority of physicists for thirty years. It shows for one thing how dangerous it is to extrapolate, to attribute—in this case—to the very small the kind of behavior that is common sense when one talks of objects of large or ordinary size; that, for example, if a particle crosses a flat screen with two holes in it, it must have gone through one to the exclusion of the other. This is not true of an electron.

The quantum theory stresses another point which is fundamental to the modern view of physics—the importance of the observer. An experiment, to be any use, must be observed. True, the immediate observer may be a photographic plate which forms a latent image to be developed and examined later, but there must be something. In other words, the scientist can only learn about the world through his senses. Theories are meant to unify sensations and in this sense explain them, but on these sensations they ultimately rest.

The observer first received proper attention in the theory of relativity. As long as there was supposed to be an ether there was a privileged observer, or class of observers—those at rest with respect to it. Without it, all are on the same footing and equally entitled to be considered. Now relativity asserts that the laws can be stated so as to be the same in form for all; no privilege is allowed.

But relativistic observers, those rather strange creatures who go about with clocks and measuring rods making signals, are not supposed to alter what they observe. The quantum observer does. Or more precisely, the circumstances that attend observation—for example, the light that is required—alter what is observed and in a manner which cannot be determined even after the observation has been made. In consequence the knowledge that can be acquired is limited, because each observation upsets something else one would like to know. This was the first real hint that there are definite limits to scientific knowledge, limits not dependent on human patience or ingenuity. The argument depends, as all physicists know, on the finite size of Planck's quantum of action, but a very similar conclusion might have been reached before the quantum theory was thought of.

I think it is curious that physics remained deterministic in philosophy as long as it did. The power of accurate prediction in all systems diminishes with time. Even for the planets, those most orderly of creatures, a *Nautical Almanack* drawn up for the year 10,000 would be appreciably less accurate than one for next year. When one is interested in individual atoms this loss of accuracy can be enormous and catastrophic. Quite apart from any quantum considerations, even if one knew the positions and velocity of every molecule of a small sample of gas at one instant, one could not predict the path of a special molecule distinguished, for example, by being radioactive; one could not find, let us say, where it would first hit a wall of the vessel holding the gas. Even supposing every gaseous collision fully determinate, a small error in an original measurement mounts up, as Max Born has pointed out, with enormous speed. In a small fraction of a second all the detailed information is useless, and one can only treat the motion as one of diffusion to which only a probability answer is possible. So when time is taken into account one gets much the same result even if Planck's constant were many orders of magnitude less than it is. This kind of virtual indeterminacy is inherent in Maxwell's kinetic theory. It sets as real a limit to certain kinds of human knowledge, even given any thinkable extension of human skill, as does the quantum theory. The circumstances to which it applies are almost certainly of more human importance. The further ahead a prediction is made the less certain it becomes, and beyond a certain rough limit all that can be affirmed is a probability, often over a wide range of possibilities. It is an interesting question, for example, what is the best that could ever possibly be done in the long-range forecasting of weather. Can, say, a prediction of the weather on a particular day ten years hence ever have any validity?

Yet in some respects atoms behave in a surprisingly straightforward way. They pile together almost like spheres, like tennis balls in fact. They are slightly compressible, and their distances depend a bit on chemical relationship, but one can place them in order in molecules and still more definitely in crystals. The work which is being done by the group at Cambridge under Perutz and Kendrew is a striking example of this. They have located most of the 10,000 atoms in the vastly complicated molecule of hemoglobin, the first protein for which this has been done.

Single rows of atoms, and occasionally individual atoms, can actually be seen in the electron microscope. They seem as real, and almost as commonplace, as grains of sand.

In contrast to this matter-of-fact behavior of atoms, the electrons are strange fairylike creatures. They have no particular place; even when they are part of an atom one can at best assign them a region in which they are most likely to be found. Unless they have an unusual amount of energy they cannot be assigned a definite path. Even their approximate behavior is queer, and to treat them properly requires highly abstract mathematics.

They can be created out of the energy of radiation, but only in pairs with positive and negative charges, and the positive one soon dies in a suicide pact with another negative. In the same way protons and antiprotons can be created and disappear. Certainly other kinds of elementary particles also have their antiparticles.

I should like to conclude by referring to two ideas of a somewhat more speculative character which may prove of importance in general thought.

Mass, Energy, and Matter

The first is the relation between mass, energy, and matter. In conventional mechanics mass is the primary property of matter, even more so perhaps than extension, since it is more constant. Now, as you know, the theory of relativity made it probable that mass is energy considered from another point of view. This is expressed by Einstein's famous equation $E = mc^2$. Thus if energy is added to, or taken from, an otherwise closed system the mass of the system will increase or decrease, as the case may be, though it takes a lot of energy to make much difference to the mass. Einstein's conclusion has been abundantly confirmed by the discovery of nuclear energy and other experiments in nuclear physics. Further, as I have just said, energy can be transformed into pairs of particles of opposite sign. It began to look as if matter is just another name for energy.

It may seem paradoxical to equate energy with the property, mass, that measures inertia, but remember that in Newtonian mechanics the bullet penetrates because of its inertia, which makes it continue in its state of motion. However, mass is only one property of matter and perhaps not even the most important. There are indications—rather slight perhaps, but not to be ignored—that matter is *not* just another name for energy. The study of the many curious particles which have been found in cosmic rays and later produced in the giant so-called "atom-smashers" has shown the persistence of certain features in spite of the bewildering number of spontaneous changes which these particles undergo. Two groups of these particles have appeared such that the net number in each group remains always the same, and this in contrast to a third group for which there is no such constancy. By the phrase *net number* is meant the difference, in each case, between the numbers of the "ordinary" particles and of the antiparticles. Thus electrons are a member of one group called "leptons," to which neutrinos also belong. In reckoning the net number of electrons one subtracts the number of positrons from the number of ordinary electrons. Thus the creation of an electron-positron pair does not alter the net number. The rule states that no interaction between particles of any kind, including the photons of radiant energy and the mesons of the cosmic rays, can alter the *sum* of the *net numbers* of the three kinds of particles—electrons, neutrinos, and μ mesons—which count as leptons. A similar rule holds for the class of particles —protons, neutrons, and some others —which rank as "baryons." Leptons can never change into baryons, or reversely.

This seems a hint that underlying matter are two classes of entity, each of which indeed can appear in several different forms associated with various amounts of mass, sometimes electrically charged and sometimes not, but yet fundamentally the same. Matter is, I think, more than merely mass or energy. A neutrino has zero rest mass but yet is an entity. A piece of ordinary matter is made up of leptons and baryons in fixed numbers.

The mass of an atom at rest is a form of energy, but matter may be something extra.

Whole Numbers

This leads to one more instance of broad ideas derived from physics, my last. It is one of the strangest facts of nature that she is so fond of whole numbers. The mere existence of large classes of individuals identical in each class, such as electrons, protons, atoms of fluorine, molecules of ethyl alcohol, and many more, is surprising enough. One might expect a continuous gradation of sizes, weights, and charges. But it is not so. On the smallest scale only certain types of particles exist. The next most complicated things, atoms, are built of integral numbers of electrons, protons, and neutrons. The numbers are fundamental and characteristic. An atom of carbon is a pattern based on the number six; there are six electrons, six protons, and six, seven, or eight neutrons according to which of the three kinds of carbon atom it happens to be.

This is such a commonplace of science that one is apt to take it for granted. But surely this, and similar facts about other atoms, are most startling if one thinks. Further, the details of the pattern made by the electrons depend on another set of small integers, the quantum numbers. We cannot say yet whether this is also true of the arrangement of protons and neutrons in the nucleus, but there are indications that it may be. We are getting back to one of the earliest scientific ideas. Pythagoras taught that whole numbers are supreme.

It is worth notice that the masses of the atoms, even reckoned at rest and in the lowest energy state, show only rough regularities. The energy of formation and the mass representing it are variable, and though energy is sometimes divided into units, there is here a continuous variation, for the unit is $h\nu$ and ν can have any value. Yet even here we have units in a sense, and all photons of the same frequency have the same energy.

Molecules, again, are composed each of an integral number of atoms. It is true that at the moment of a reaction it may be difficult to say which atoms belong to a molecule, or even if the concept of molecule is valid, but few would deny its importance in general. It is a concept which, though it owes something to the desire of the human mind to simplify, yet arises almost inevitably from nature. If the Martians are competent chemists they will, sometimes at least, think in terms of molecules.

Rather the same can be said of the concept of a cell. Living matter is, generally speaking, cellular, and the cells that compose a given kind of tissue are mostly pretty much alike in size and shape. Even the organisms that they form tend, at least, to fall into species each containing very many similar individuals. In many cases, also, the component parts of an individual are multiplied—for example, scales or leaves.

While the "atomicity" of electrons is perfect in the sense that each is in principle indistinguishable from any other, and the possibility of exchange without resulting difference is built into the theory, the atomicity of members of a species, of cells, and even of molecules is less rigid, but concepts embodying it are highly useful and represent something real in the world.

At present one can only speculate as to how far the complete atomicity of the elementary particle causes the partial atomicity one sees in biology, or for that matter in astronomy. If it is *not* a sufficient explanation, then we must look even deeper than the elementary particles for this principle of atomicity, which would make it very fundamental indeed.

Conclusion

I have tried in this address, in a very discursive fashion, to remind you of a few of the ways in which science has provided, and is providing, new ideas tied closely to experience, though often experience of a special character.

These ideas constitute an achievement of which man may well be proud. It is surely something for beings so utterly insignificant by comparison with the smallest of the stars that are scattered with reckless abandonment in the heavens to be able to understand some, at least, of the principles which control their existence and enable us to perceive them.

To see these principles as applying equally on earth, as manifest in the most varied phenomena—in the motions of the tides, in the blue of the sky, in the lightning flash, and in the falling apple; to prove our understanding by creating, on however small a scale, compositions of our own which use these principles in new ways of our own devising; to be beginning to see some light on the nature of living matter and how living forms can transmit themselves to descendants — all these are worth while and worthy to rank with the achievement of sculpture, of music, or of literature.

Science is not merely the control but also the understanding of nature. Its two aspects must be held in equal honor.

Science in the News

Disarmament: America Is Finding That Its Proposals Have Less Appeal Than Those of the Soviet Union

From New York. The United States is finding itself in an awkward position on the disarmament question at the United Nations. For there is a widespread impression here that the United States is not yet ready to deal with the problem of disarmament, that the United States is interested only in controls over existing armaments. The Russians, on the other hand, have been talking disarmament at every opportunity, and although there is a great deal of skepticism regarding the Russian intentions, the Russians nevertheless are holding the initiative.

Speaker after speaker refers to disarmament as the main problem before the world. And logical as the American insistence on gaining experience on means of control and inspection may be, it does not have a very favorable effect on this war-worried assembly where it is accepted by everyone that controls are necessary but where the Russians have managed to put themselves in the position of advocating controlled disarmament while the United States, fairly or not, is widely regarded as advocating merely controlled armament. "It is perfectly clear," Nehru told the General Assembly last week, "that disarmament without controls is not a feasible proposition. It is even more clear that controls without disarmament have no meaning." "It is not proposed, I hope," said Nehru, "to have controls of existing armaments and thus in a way to perpetuate those armaments."

In fact, there is good reason to believe that the basic attitudes of both the United States and Soviet Union regarding disarmament are essentially the same. That attitude is one of great skepticism. It is based on the awareness of both sides of the pitfalls inherent in almost any disarmament proposal and on the feeling on both sides that progress would be enormously difficult even if there were a great deal more good will in the air than is the case this week.

Given this skepticism on both sides, there is a good case to be made that the United States position is more realistic and more likely to decrease the chance of war. As noted in earlier reports in this space, the United States is putting an increasing amount of effort into the search for stability and into reducing the likelihood of war. The Russians appear to be taking this larger problem less seriously than we are. And, again quoting Nehru's speech to the General Assembly, "we must always remember that even in pursuing disarmament we have to keep in view our larger purpose [of avoiding war]."

The difficulty with the United States position is this: on the less sophisticated level the Russians' emphasis on disarmament has an enormously greater emotional appeal than the American emphasis on controls; on a more sophisticated level the principal criticisms, and they can be heard from Westerners as well as neutralists, are that even granting the validity of the arguments pointing up the pitfalls of any disarmament scheme anyone has yet suggested, it can still be argued that the disaster of nuclear war would be so enormous that the United States should be willing to risk more than it has been up till now to make some progress on actual disarmament. Beyond this, the critics say, even granting that the American search for stability is more valid than the Soviet talk of grandiose disarmament schemes, the usefulness of the American stability proposals tends to be dissipated when it is so easy for the Russians to brand them as mere diversions by the United States to avoid coming to grips with disarmament proper.

Sources of Difficulty

There are a good many factors to explain the American position, but unfortunately few of them are things that American spokesmen are anxious to talk about in public. The basic source of American difficulty is this: Both the Americans and Russians are pessimistic about what can actually be achieved in the way of disarmament and skeptical of the actual value of disarmament in lessening the risk of war. Therefore neither side feels it can really risk anything important in the hope that disarmament will really go forward and that it will be a useful step.

But the United States, completely aside from disarmament, is anxious to push the Russians into opening up their country to foreigners, which makes the United States delighted to urge measures of inspection and control, completely aside from their undoubted importance toward paving the way for progress on disarmament.

The Russian point of view, of course,

is completely the opposite. The Russians recognize that they have a strategic advantage in their closed society. They are deeply suspicious that the United States really is interested in controls and inspection in order to gather intelligence information, and their argument that the United States is more interested in espionage than in disarmament carries greater weight with the uncommitted nations as a result of the U-2 incident.

Cost of Armaments

The Russians argue that they want the West to agree to some specific commitments on disarmament and that they will then sit down and work out the necessary control arrangements. The Russians are spending roughly the same amount of money on arms as the United States. But since the Soviet national income is less than half that of the United States, this means the Russians are spending about 25 percent of their national income on arms against only about 10 percent for the United States. Arms, therefore, are a heavier burden on the Russians than on ourselves, and it is in the Russian interest, completely aside from the question of whether the kinds of disarmament achieved will actually reduce the likelihood of war, for the Russians to try for some sort of arrangement that will reduce this burden.

Controls

The United States is as suspicious of the Russians' proposals for an immediate start on disarmament as the Russians are of our proposals for a preliminary period in which both sides can gain experience in working out effective control systems. If nothing else, we suspect that the Russians, once they have gotten an American commitment on some disarmament measures, will then refuse to agree to acceptable controls. This would leave the United States in the position of either having to accept disarmament on Russian terms, with inadequate controls, or of disappointing the world by backing out of the disarmament agreement. Many Americans fear that this is exactly what is happening at the Geneva test ban talks.

What all of this amounts to is that with neither side having much optimism about the possibility of real and useful progress on disarmament; and with neither willing, for this reason, to take substantial risks in order to move toward disarmament, both sides have been putting forward proposals which are essentially self-serving. The proposals of both sides can be easily accounted for simply in terms of national self-interest, completely divorced from the mutual interest of both sides in avoiding a nuclear war. The United States can justly claim to hold the more reasonable position on the broader and more important questions of world stability and lessening the chances of war, but on the question of disarmament proper neither side can lay much claim to a clear position of moral leadership.

Unfortunately for the United States, though, our self-interest leads us to talk mostly about controls, while the self-interest of the Soviet Union leads the Russians to talk mostly about immediate steps toward actual disarmament. As noted above, the Soviet talk of disarmament has a far greater emotional appeal than the American talk of stability and controls.

What is more, the basic tactical advantage of the Russians in terms of what national self-interest leads the two sides to propose is only the beginning of the source of American awkwardness on the disarmament problem. A summary of the principal remaining difficulties will appear in this space next week.

Pauling and the Senate Committee

Linus Pauling returned to Washington this week to answer the subpoena of the Senate Internal Security Subcommittee. Pauling, as he has always said he would, refused to give the committee the names of those who helped him gather signatures for his 1957 petition to ban nuclear testing.

At a press conference the day before the hearing Pauling appeared to be virtually challenging the committee to cite him for contempt. He said that those who opposed his views were trying to prepare the American people for nuclear war and that they wanted to continue the cold war, "to make billions of dollars in profits." He announced that he would not answer the committee's subpoena because the Supreme Court had not yet acted on his petition for a judgment on whether the committee had a right to demand the names, although lower courts had already ruled that his request was premature and Chief Justice Warren had declined to order a stay of the hearing. A few hours later, though, Pauling changed his mind and announced that he would appear at the hearing after all.

The next morning, at the hearing, Thomas Dodd of Connecticut, the acting chairman, was the only Senator present. Dodd is a liberal Democrat on domestic economic issues. On foreign policy he is one of the most consistent critics of a policy of trying to negotiate agreements with the Russians, which places him in opposition to Kennedy, Nixon, and the great majority of the country's political leaders. He has been as wholly opposed to a test ban as Pauling is committed to it.

But the hearing was marked by restraint on both sides. Pauling made no remarks like those of the press conference the day before. Dodd consistently ruled in favor of Pauling and against subcommittee chief counsel Sourwine on a number of questions of what documents should or should not appear in the record. Dodd rebuked the committee staff for distributing a summary of Pauling's activities under the heading of "Communist and Communist front activities," ordering instead that it be headed merely "certain activities." After the hearing, Pauling told Dodd that he thought he had been fairly treated.

The hearing dragged on for nearly 4 hours after Pauling, at the very beginning of the questioning, had refused to supply the names on the legal grounds that to do so under the circumstances could hardly fail to inhibit people who might like to circulate future petitions on unpopular or controversial matters. The remainder of the hearing was devoted to questions from committee counsel Sourwine about Pauling's past associations and activities, none of which turned up anything that really justified the title the committee staff has given the hearings: Communist Infiltration and the Use of Pressure Groups.

The Supreme Court recently supported a position similar to Pauling's when it ruled unconstitutional a California law requiring that pamphlets and leaflets must bear the names of their authors and of those responsible for distributing them. The court ruled that the law would tend to inhibit the freedom of expression of unpopular opinions guaranteed by the Bill of Rights. But the courts grant special leeway to legislative investigating committees, so it is not clear that the courts will uphold Pauling's position if his request for a declaratory judgment is granted or if the committee should cite him for contempt and bring him to trial.—H. M.

News Notes

U.S. Courier Satellite Marks Third Anniversary of Sputnik I; Inter-Agency Rivalry Emerging

The Army sucessfully orbited a 500-pound Courier communications satellite from Cape Canaveral, Fla., on 4 October. During its first circuit of the earth the vehicle transmitted a message from President Eisenhower to Secretary of State Herter at the United Nations, marking the third anniversary of the launching of the first satellite, the U.S.S.R.'s Sputnik I, and the opening of the space age. Many Western scientists have been expecting the Soviet Union to commemorate the occasion with yet another space triumph, but no announcement has been made.

The United States has so far launched 26 earth satellites and two deep space probes. The Soviet Union has fired six earth satellites (each many times heavier than those of the United States), one deep space probe, and a successful moon shot.

The new Courier has further increased the prospects for improved international communication. An earlier step was the successful launching, in August, of the National Aeronautics and Space Administration's balloon satellite Echo, which reflects radio signals between two widely separated points. The Courier, known as a "delayed repeater," is an active satellite that sends and receives messages. When it is in sight of a ground station, it can operate at the rate of 372,500 words in a 5-minute period. Messages are stored on tape recorders in the satellite and transmitted back to earth on command when the vehicle is over the next station.

The Courier experiment is part of the preparation for the Army's Project Advent, in which it is planned to space three 1-ton satellites above the equator at an altitude of 22,500 miles so that each will remain over a single spot on earth, moving at the speed at which the earth rotates.

Agency Rivalry

The Echo and Courier have raised the possibility of a jurisdictional controversy between NASA and the Army over the conduct of the communications satellite program. Heretofore, the military and civilian programs have been clearly defined, the first being devoted to active satellites and the second to passive. Now, however, it has been reported that NASA is considering work on active communications satellites. The space agency's tentative plans have aroused the concern of the Senate Aeronautical and Space Sciences Committee, which is drafting a report warning of the danger of duplication of effort in the development of communications satellites, as well as in other fields such as manned space flight.

More Neanderthal Skeletons Found in Shanidar Cave, Iraq

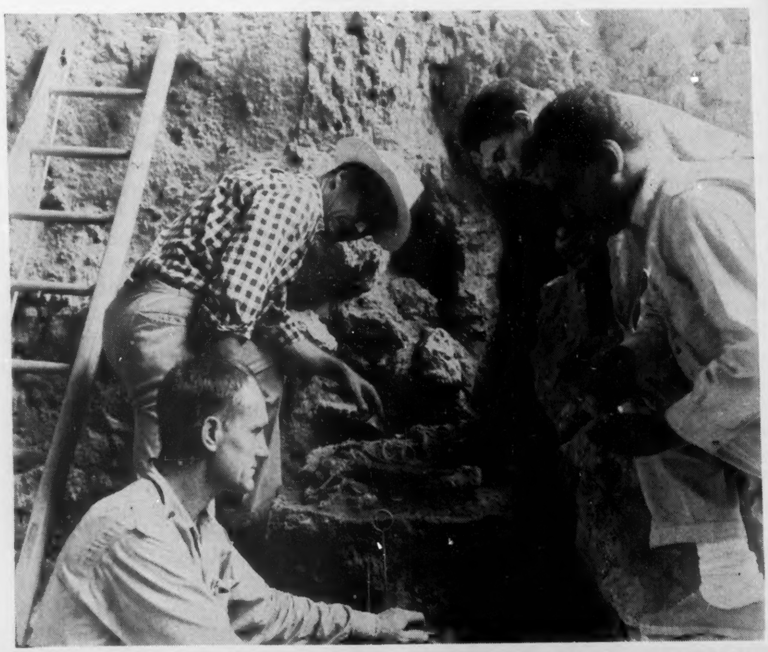
Columbia University anthropologists have discovered three additional skeletons of prehistoric men in Shanidar Cave in northern Iraq, which yielded three Neanderthal skeletons in 1957 and the skeleton of a prehistoric infant in 1953. An expedition led by Ralph Solecki, assistant professor of anthropology at Columbia, also discovered a burial place with 26 skeletons, date palm pollen, wild wheat, and additional evidence of a change from cave to village life.

The excavations were made near Shanidar, a small Kurdish village of about 150 persons in the Zagros Mountains, 250 air-line miles north of Baghdad, Iraq, near where the borders of Iraq, Turkey, and Iran meet. The expedition was cosponsored by Columbia University and the Smithsonian Institution, under a research grant from the National Science Foundation.

Solecki commented that the new finds, like the ones of the 1957 season, probably represent a "conservative" type of Neanderthal who became extinct in northern Iraq about 45,000 years ago. He said that it is possible that the Zagros mountain area may have been a refuge for these prehistoric people, since there is geological evidence suggesting that in Palestine a more humanly advanced "progressive" Neanderthal was already in existence long before this time. He observed:

"The Neanderthal skeletons of Shanidar Cave give us physical evidence of the Mousterian [stone-age] culture bearers whose artifacts in Iraq were first found at the cave of Hazer Merd near Sulaimaniya [in Iraq, about 100 miles south southeast of Shanidar] more than 30 years ago. The finds are important to human paleontological studies, especially since their very number represents a population series for comparative study."

The cave lies at an altitude of 2500 feet. It provides good, but airy, shelter



Ralph Solecki, T. Dale Stewart (in checkered shirt), Jacques Bordaz, a graduate student at Columbia, and a representative of the Iraqi government, in Shanidar Cave examining one of the seven skeletons of prehistoric man found there.

and is comparatively dry and well-protected from the weather, with a southern exposure. The expedition's excavation, sunk in the center of the floor area, was graduated down in steps to a depth of 45 feet, where bed-rock was encountered. The surface area of the pit measures 20 to 30 feet wide and 80 feet long. Solecki said that shepherds dumped debris into the excavation after the 1957 season, and the scientists and their party spent a month this year cleaning it out.

All of the seven Neanderthal skeletons were found in the lower level of the sediment, dated 45,000 and more years ago. The lowest skeletons were 10 to 12 feet deeper than the others and were estimated geologically to be about 70,000 years old, while the upper ones were found by carbon-14 methods to be about 45,000 years old. The skeletons are more complete than are usually found—virtually whole ones fairly well preserved. Only about one-tenth of the cave has been excavated; excavation of the remainder is expected to provide other specimens.

Six of the skeletons have been sent to the directorate general of antiquities of Iraq in Baghdad. Arrangements have been made for the seventh to be sent to T. Dale Stewart, a member of the expedition, at the Smithsonion Institution. Solecki also has arranged for shipment to him of a case of animal bones for study by zoologists and a case of soil samples for study by geologists.

Office for Japanese-American Science Cooperation Opens in Tokyo

Two representatives of the National Science Foundation, Robert T. Webber and Henry Birnbaum, have been assigned to the staff of the American Embassy, Tokyo, to establish an office to assist in promoting exchange of scientific knowledge between scientists and institutions in Japan and the United States. They will act as an integral part of the embassy in close cooperation with the science attaché, Willis R. Boss.

As part of their duties, the two men will study and report on Japanese science organization and funding, both private and governmental, and will make similar information on American science available to Japanese scientific institutions. One of their principal functions will be to develop and promote the exchange of scientific information of a documentary nature. In this connection, they will assist in the publication in English of scientific articles and abstracts written by Japanese scientists and will support activities for translating and abstracting existing Japanese science information into English. They will also encourage the exchange of scientists between Japan and the United States and will arrange surveys, reviews of research, and science education activities.

Inter-Agency Policy Disagreement

Establishment of the new office is the outcome of long-standing policy disagreement among several government agencies. In recent years the upsurge of Japanese science has prompted a number of United States officials to urge the setting up of a scientific liaison office in Japan.

Last year the Office of Naval Research, which has for some years operated a large and successful office in London for European science cooperation, launched plans to form a similar unit in Tokyo. The State Department objected, however, on the grounds that in the present political climate such an office should not function under military auspices. Nevertheless, there have been recent reports that the Department of Defense may also open a scientific office in Japan.

Educators Recommend Broader Science Programs in Public Schools

Science education for American children and youth must begin in kindergarten and continue through the 12th grade. The recently published report of the science manpower project of Teachers College, Columbia University, urges that science be made a "fourth R" in the early program of general or liberal education. It recommends that science education should begin in kindergarten, and must be given the same importance as reading, writing, and arithmetic in the six elementary grades. For the junior high school, a 3-year program in general science for all students is recommended.

In the senior high school, science should be designed for three groups of students: those who will complete their education with high school, an academic group who will go on to college, and a special academic group with "marked science interest and aptitudes."

The report, *Policies for Science Education*, was prepared by a group drawn largely from the ranks of professional educators concerned with the teaching of science. They worked under the direction of Frederick I. Fitzpatrick, head of the department of the teaching of science at Teachers College. Fitzpatrick is editor of the report and director of the science manpower project.

The science manpower project was organized 4 years ago to help improve the teaching of science in the nation's schools. It is supported largely by a group of leading American industries and foundations. The report recommended, among other things, stiffer requirements for science teachers, opposition to the pressure of parents to establish "easier" programs for their children, and a shift away from the tendency to regard science and mathematics courses as electives that the student can easily avoid taking.

Science Information Exchange Organized

A Science Information Exchange has been established within the Smithsonian Institution. It was organized in late September by representatives of the Public Health Service, Department of Defense, National Science Foundation, Veterans Administration, National Aeronautics and Space Administration, Atomic Energy Commission, as well as of the Smithsonian. The new organization developed from an expansion of the successful Bio-Sciences Information Exchange, which has been a cooperative enterprise under the aegis of the Smithsonian, with the financial support of the above-mentioned agencies, for the past 7 years.

Orr Reynolds, director of the Office of Science, Defense Research and Engineering, Department of Defense, was elected chairman of the governing board for the coming year, and Lyndon Lee, coordinator of research in surgery, and chief, Extra V. A. Research Division, Veterans Administration, was made vice chairman. Stella L. Deignan, director of the Bio-Sciences Information Exchange since its initiation, will be the director of the staff of the expanded agency.

The basic purpose of the Science Information Exchange, as stated in the agreement between the participating agencies, is as follows: "To foster and facilitate effective planning and management of scientific research activities supported by United States agencies and institutions by promoting the exchange among participating agencies of administrative data about all types of current research. This process will include the accumulation, organization, analysis, and distribution of pertinent information and data concerned with all types of research within the scope of the Science Information Exchange."

The exchange will make available information on research in progress that has been filed with the exchange to its supporting agencies and other qualified investigators. It plans to spend the months immediately ahead working out procedures for the inclusion of the physical sciences in its program. It is expected that the actual scope of coverage and service, by subject matter and by types of research projects, will evolve and expand gradually.

News Briefs

U.N. oceanographic study. The United Nations is planning an extensive study of the world's major bodies of water. Fish will be counted, fertility and productivity studied, and the floors of oceans mapped. Roger Revelle of the Scripps Institution of Oceanography, a member of the national committee of the United Nations Educational, Scientific and Cultural Organization, recently announced plans for the international cooperative program, which is expected to cost contributory nations a total of $20 million a year. UNESCO will provide $500,000 for the first 2 years of operation.

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Smog warning. Advance warning of impending severe smog conditions is now available to all cities east of the Rocky Mountains under a new cooperative network operated by the Weather Bureau, the Department of Commerce, and the Public Health Service. Thirty-six States will be able to get warning bulletins by teletype from the Weather Bureau Research Station, located at the Public Health Service's Sanitary Engineering Center in Cincinnati.

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Botanical museum closed. Since 15 June the museum building of the New York Botanical Garden, which houses the museum, the library, the herbaria, and the paleobotanical collections, has been temporarily closed to visitors. The extensive renovation work undertaken by the Department of Parks of the City of New York is expected to be completed in time for the building to reopen by about 1 January 1961. Meanwhile, the administrative and scientific staff have found temporary quarters in other buildings of the garden, and a skeleton library of reference works and current publications is available.

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NASA materials research. The National Aeronautics and Space Administration has announced the establishment of a Materials Research Programs Division. Reporting to the assistant director for structures and operating problems in the Office of Advanced Research Programs, the division assumes responsibilities previously fulfilled by elements of both the propulsion and structures divisions. George C. Deutsch, formerly head of the Refractory Materials Branch at NASA's Lewis Research Center, is chief of the new division.

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Biological teaching films. The University of California has announced the release, for rent or sale, of two new teaching films: *The World Within*, a general introduction to the study of parasitology, and *The Life and Death of a Cell*, which describes modern cell theory. For information, write to the Department of Visual Communication, University Extension, University of California, Los Angeles 24, Calif.

* * *

Research dog hero. On 1 November the board of directors of the National Society for Medical Research will select the Research Dog Hero of 1960. Nominations for the award may be made by anyone. The research dog must be alive, have participated in important scientific work, and preferably be now either a pet or at least allowed the freedom of the institution's animal quarters. Nominations must be received by 30 October at society headquarters, 920 South Michigan Blvd., Chicago 5, Ill.

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Nutrition examinations. The American Board of Nutrition will hold the next examinations for certification as a specialist in human nutrition on 10 April 1961 in Atlantic City. Application forms, which must be returned by 1 March, may be obtained from the secretary, Robert E. Shank, M.D., Department of Preventive Medicine, Washington University School of Medicine, Euclid and Kingshighway, St. Louis, Mo.

Grants, Fellowships, and Awards

Endocrinology. The American Institute of Biological Sciences has received funds that will enable it to award travel grants to approximately 25 American scientists desiring to attend a symposium on comparative endocrinology in Oiso (Tokyo), Japan, 6–10 June 1961. Application blanks may be obtained from AIBS, 2000 P St., NW, Washington, D.C., Attention: Dr. John R. Olive. Applications must be filed with AIBS *before 30 November*.

General, for women. The American Association of University Women has announced its 1961–62 program of fellowships for women of the United States. The awards are open to women who hold the doctorate, or who will have fulfilled all the requirements for the doctorate except for the dissertation by the time the fellowship year begins, or who have attained professional recognition. Fellowships are unrestricted as to age or field and may be used abroad or in the United States.

Forty fellowships are available: one for $5000, four for $4000, ten for $3000, and 25 for $2000 to $2500. Applications must be filed *before 1 December*. For information, write to: Fellowships Office, AAUW Educational Foundation, 2401 Virginia Ave., NW, Washington 7, D.C. (Information about international fellowships and grants offered for women of other countries may be obtained from the same address.)

Laboratory equipment. Scientists and science teachers in colleges, universities, and nonprofit organizations have been invited by the National Science Foundation to submit proposals for the development of prototypes of new laboratory equipment for use in the nation's primary and secondary schools and in colleges. Proposals signed by the project director and a responsible officer of the sponsoring college, university, or scientific organization should clearly describe the work to be done, give the qualifications of the personnel involved, show how the proposed device will be tested and eventually made generally available, and present a detailed budget.

Support under this program will not be provided for the purchase of equipment for refurbishing school and college laboratories, or for commercial production of equipment or materials. Although proposals may be submitted at any time, those to be considered for support during the current fiscal year should be sent *before 15 December* to the Course Content Improvement Section, Division of Scientific Personnel and Education, National Science Foundation, Washington 25, D.C.

Scientists in the News

William W. Rubey, one of only three specially appointed staff research geologists at the U.S. Geological Survey, has resigned to take up a new post as professor of geology at the University of California, Los Angeles, after a distinguished career with the Survey that began in 1920 when he became a geologic aide. Rubey, whose most recent public recognition was an honorary degree from Yale University in June, is a member of the National Science Board and of the AAAS Board of Directors. He will retain a part-time affiliation with the Geological Survey.

Rubey's principal interests and accomplishments have centered around geologic principles and processes; his research has ranged widely over such diverse fields as petroleum geology, geomorphology, principles of sedimentation, the causes and results of mountain building, economic geology, and oceanography. He made the initial geologic study of the Cliffside field of Potter County, Tex., which proved to be the nation's outstanding helium reserve. All gas rights in the field were acquired by the government, and the operations of the Amarillo helium plant since its opening in 1929 have been based on the production of the Cliffside fields.

William W. Rubey

H. Stanley Bennett

H. Stanley Bennett, professor and chairman of the department of anatomy at the University of Washington, Seattle, has been appointed dean of the division of the biological sciences at the University of Chicago, effective 1 January 1961. He will succeed **Lowell T. Coggeshall**, who held the deanship for 13 years. Coggeshall was appointed the university's vice president for medical affairs last March.

Bennett, an internationally recognized biologist who is immediate past president of the American Association of Anatomists, is widely known as a specialist in cellular anatomy and cytochemistry. His work with the electron microscope has yielded fundamental new knowledge of how human muscles work.

Louis P. Hammett of Columbia University, one of the nation's foremost physical chemists, has won the American Chemical Society's 1961 Priestley Medal, highest honor in American chemistry. The gold meal will be presented to Hammett "for distinguished services to chemistry" at the American Chemical Society's 139th national meeting in St. Louis in March.

Hammett's research, chiefly on the speed of chemical processes and the arrangement of atoms within molecules, has helped clarify the theory of acidity and added to knowledge of chemical reactions in solutions. As a wartime contributor to national defense, Hammett worked on explosives and rocket propellants. He also is widely recognized for his accomplishments as an educator and administrator.

Karl K. Darrow, who retired from the technical staff of Bell Telephone Laboratories in 1956, has received the Karl Taylor Compton Gold Medal, the highest honor of the American Institute of Physics. The Compton medal, which has been awarded only once previously, is granted for "high statesmanship in physics." Darrow was cited for his devotion to physics "in ways without precedent or parallel," in a ceremony at the Arden House of Columbia University, Harriman, N.Y. Darrow, who served nearly 40 years with the Bell System, has been secretary of the American Physical Society since 1941.

Six winners, including two radio stations, have been named by the American Heart Association to receive its 1960 Howard W. Blakeslee awards for outstanding reporting on heart and circulatory diseases. The awards will be presented at a luncheon of the association's Council on Community Service and Education at the Sheraton-Jefferson Hotel in St. Louis on 22 October in conjunction with the annual meeting and scientific sessions of the association. The winners, each of whom will receive a citation and an honorarium of $500, are as follows.

Barbara Milz, newspaper reporter, for a six-part series in the Augusta, Ga., *Chronicle* (December 1959) describing open-heart surgery and the research advances which combined to make possible a successful heart operation. (Mrs. Milz is at present with the Atlanta *Constitution.*)

Francis Bello, for his *Fortune* magazine article, "How good is Mr. Hurley's diet?" (December 1959), dealing with the relationship of diet and coronary disease and presenting the latest medical opinions on this subject.

H. M. Marvin, associate clinical professor of medicine, Yale University School of Medicine, and past president of the American Heart Association, for his book, *Your Heart: A Handbook for Laymen* (Doubleday), which improves public understanding of the heart and circulatory diseases.

Isaac Asimov, free-lance writer, for his book about the circulatory system, *The Living River* (Abelard-Schuman), which explains for the layman the manifold activities of the human bloodstream and their relationship to the structure and disease of the heart and circulation.

"A new life for Larry," radio program presented 1 July 1959 by KMOX, St. Louis, Mo., which dramatized a significant research achievement through the documentary account of an operation inside the heart of a 5-year-old boy.

"Close to the heart," a television film presented 21 February 1960 by WCSH-TV, Portland, Me., which illustrated progress in heart research including new advances in heart surgery.

Arne Tiselius, Nobel Prize winning director of the Institute of Biochemistry, University of Uppsala, Sweden, is in this country to discuss special research in protein chemistry, electrophoresis, and absorption with scientists of the Army Research Office and the Army's technical services. He will also confer with investigators at the Quartermaster Research and Development Command, Natick, Mass., and the U.S. Army Medical Center at Walter Reed Hospital.

Jacques Monod, professor of biochemistry at the Sorbonne and *chef du service* at the Institute Pasteur, Paris, is at the University of Oregon this month as visiting lecturer in biology in the Institute of Molecular Biology.

Twenty-three men will be honored by the Franklin Institute at its annual Medal Day on 19 October. With the exception of the Franklin Medal, the awards are presented in the order in which they were founded.

Franklin Medal (1914): **Roger Adams**, research professor of chemistry emeritus, University of Illinois, Urbana, for his contributions to organic chemistry.

Elliot Cresson Medals (1848): **Hugh L. Dryden**, deputy administrator, National Aeronautics and Space Administration, for contributions to aerodynamics and guided missiles; **Arpad L. Nadai**, formerly consulting mechanical engineer, Westinghouse Research Laboratories, Pittsburgh, Pa., for contributions to elasticity and plastic flow of materials; and **William F. G. Swann**, director emeritus of the Franklin Institute's Bartol Research Foundation, Swarthmore, Pa., for cosmic ray investigations; also a Certificate of Merit (1882) to **Richard R. Moore**, chief metallurgist, Naval Air Engineering Facility, Naval Air Material Center, Philadelphia, Pa., for fatigue testing of materials.

Edward Longstreth Medals (1890): **W. Edward Chamberlain**, special assistant to the chief medical director for atomic medicine, Veterans Administration, Washington, D.C., for contributions to radiological engineering; **John W. Coltman**, associate director, Research Laboratory, Westinghouse Electric Corporation, Pittsburgh, Pa., for contributions to the x-ray image amplifier; **Frederick A. Keidel**, research project engineer, Experimental Station, E. I. DuPont de Nemours & Co., Wilmington, Del., for development of an electrolytic moisture analyzer; and **Moulton B. Taylor**, president, Aerocar, Inc., Longview, Wash. for development of a flying automobile.

Howard N. Potts Medal (1906): **Charles S. Draper**, professor and head of department of aeronautics and astronautics and director of the instrumentation laboratory at Massachusetts Institute of Technology, for contributions to inertial navigation.

Louis E. Levy Medals (1923): **Ezra S. Krendel**, manager, engineering psychology laboratory, Franklin Institute Laboratories for Research and Development, Philadelphia, and **Duane T. McRuer**, president, Systems Technology, Inc., Inglewood, Calif., in recognition of their paper on the human operator as a servo system element.

George R. Henderson Medals (1924): **Ernest Chatterton**, engineering consultant, formerly chief engineer, D. Napier and Son, Ltd., London, England, and **Herbert Sammons**, managing director, D. Napier and Son, Ltd., for their development of the "Deltic" diesel-electric locomotive.

John Price Wetherill Medals (1925): **Raymond Castaing**, staff member, Laboratoire de Physique des Solides, Université de Paris, France, for development of the electron probe microanalyzer; **Walter Juda**, executive vice president and technical director, Ionics, Inc., Cambridge, Mass., for development of a commercial method of desalting saline water; and **Victor Vacquier**, research geophysicist, Scripps Institution of Oceanography, University of California, La Jolla, for his development of the first practical airborne magnetometer.

Walton Clark Medals (1926): **Robert W. Cook**, vice president, C. W. Fuelling, Inc. Decatur, Ind., and **Lee F. McBride**, C. W. Fuelling, Inc., Decatur, Ind., for their development of a leak-sealing system for gas mains.

Frank Brown Medal (1938): **R. Buckminster Fuller**, structural designer, Forest Hills, N.Y. for his inventive conception of the geodesic domes.

Stuart Ballantine Medals (1946): **Rudolf Kompfner**, director of electronics and radio research, Bell Telephone Laboratories, Inc., Holmdel, N.J., and **John R. Pierce**, director of research (communications principles), Bell Telephone Laboratories, Inc., Murray Hill, N.J., for their development of the traveling wave tube amplifier; and **Harry Nyquist**, formerly assistant director of systems studies, Bell Telephone Laboratories, Inc., Murray Hill, N.J. for his contribution to electrical communication engineering.

Allan D. McKnight, executive commissioner of the Australian Atomic Energy Commission, was made chairman of the Board of Governors of the International Atomic Energy Agency at the first meeting on 3 October of the newly elected board.

Guerogui Nadjakov of Bulgaria and **Carlos Graef Fernandez** of Mexico are vice chairmen.

The board also appointed a scientific advisory committee whose members include **Isidor I. Rabi** of the United States, **W. B. Lewis** of Canada, **Homi J. Bhabha** of India, **Vasily S. Yemelyanov** of the Soviet Union, **Bertrand Goldschmied** of France, Sir **John Cockcroft** of Britain, and **Louis Cintra do Prado** of Brazil.

Herbert Freeman, former head of the military data processing department of the Sperry Gyroscope Company, Great Neck, N.Y., has been appointed associate professor in the department of electrical engineering at New York University (Bronx).

Terance Charles Stuart Morrison-Scott was appointed director of the British Museum (Natural History) last spring, succeeding Sir **Gavin De Beer**.

Recent Deaths

Norman Bauer, Logan, Utah; 45; professor of chemistry at Utah State University; 9 Sept.

Russell D. Herrold, Chicago, Ill.; 72; professor emeritus of urology at the University of Illinois College of Medicine; 29 Sept.

Hermann I. Schlesinger, Chicago, Ill.; 78; emeritus professor of chemistry at the University of Chicago, and leader in jet and rocket fuel research; recent recipient of two of the top honors in American chemistry—the American Chemical Society's 1959 Priestly Medal, and the Willard Gibbs Medal awarded by the society's Chicago chapter; 29 Sept.

Herman A. Wagner, Chicago. Ill.; 94; consulting mining and metallurgical engineer.

Book Reviews

The Making of the Broads. A reconsideration of their origin in the light of new evidence. J. M. Lambert, J. N. Jennings, C. T. Smith, Charles Green, J. N. Hutchinson. Preface by H. Godwin. Royal Geographical Society, London, 1960. 153 pp. Illus. 25s.

This is a remarkable study. The origin of the lakes known as *the broads*, which occupy portions of a number of river valleys adjacent to the North Sea coast and west of Norwich, England, has long posed a problem. In an earlier report based on a study of the vegetation and geology of the broads in the valleys of the Ant and Bure rivers, Jennings and Lambert suggested that the broads formed as natural lakes beyond the limits of an estuarine clay deposited during a recent transgression of the sea. Subsequent work by the authors on the relation of the vegetation to the underlying deposits helped to explain admitted gaps in the original theory and brought many new features to light. With the progress of detailed investigation of the stratigraphy of the broads in the Yare, Waveney, and Thurne valleys, the authors became convinced that the broads were the work of man, not of nature. Although the stratigraphy of the area was clearly revealed, hitherto reported local history provided no corroborative evidence for the new hypothesis.

However, study of early records by Smith disclosed the existence of an active peat industry in the area during the 12th century, which continued, although declining, into the 15th century. Still unclear was the probable time of the origin of the turf cutting and a reconstruction of the environmental relations of land and sea which would make possible the cutting of peat to depths varying from 6 to 16 feet over 2600 acres in an area now regularly subject to inundation. The remaining clue to the mystery was provided by the archeological evidence. The distribution of artifacts and a stratigraphic section in the vicinity of Yarmouth clearly indicate that from about the 7th to the 13th century the land stood 13 feet higher relative to the sea than it does today.

Each part of this study could stand alone, but the way in which detailed and specific aspects of stratigraphy, physiography, history, and archeology have been related to provide an elegant explanation of these conspicuous features of the landscape makes it particularly interesting to me.

The artificial character of the broads was originally suggested by the vertical walls of the basins, the presence of steep-sided blocks of peat occurring as islands within the basin or as continuations of the undisturbed alluvium, and the remarkably uniform depth of the basins, 3 to 4 meters below the present surface, as well as by their rectilinear margins, and their nearly horizontal floors. In addition, the peat and mud deposits of the basins eventually were recognized as unconformable to the surrounding and underlying peat, clay, and silt. The following interpretations are made: the vertical sides are the abandoned workings of the face; the undisturbed deposits were ridges used as causeways separating the workings; and the even depth of excavation suggests the limits to excavation posed by the presence of water. Boundaries shown on 19th-century tithe-award maps were found to coincide with patches and lines of vegetation still visible in some of the broads. In addition, although the association of the broads with the present pattern of the rivers and valleys initially suggested a natural origin, the characteristics of specific basins and the classification of the varied kinds of sites subsequently suggested to the authors that human activity would be governed by the distribution of peat which, in turn, reflected the underlying physiographic pattern.

Sixteenth century maps of the region showed specific broads, and nothing in the place names, or in the traditions of the area, suggested the turf-pit origin of the broads. Smith indicates that the word *broad* was applied to the area in a history written about 1670, and several 16th-century maps indicate the stability of the outline of several of the basins. However, search of the register of St. Benet's Abbey (the ruins of the abbey still remain) revealed the existence of a turf industry in the 12th century. These are the earliest references recorded. From records of the Norwich Cathedral Priory, from tithe records, and later from court rolls, deeds, and leases, Smith reconstructs the economy of peat production, including the approximate area covered, the costs and procedures involved in preparing the peat for use, the use of and the trade in peat, and estimates of the production. Using admittedly hypothetical estimates, based on population, probable use, amount removed, and rates of production of peat, the author concludes that the digging of the broads by hand is a "feasible possibility" over a period of several centuries.

Accounts of flooding in 1287 coincide with a beach deposit dated as 13th century by pottery. These physical events, in turn, coincide with the increased use of a scoop for digging peat under water and with increased costs of production associated with collection and preparation of peat in pits subject to inundation and standing water. This gradual submergence constitutes the beginning of the formation of the broads or lakes.

Inasmuch as the historical record begins at the time peat production had probably already reached a peak, the date of its initiation demanded evidence from another source. In part 3 of this study Greene has mapped separately the distribution of population in the estuary during six periods: Neolithic, Bronze Age, Early Iron Age, Romano-British, Early Anglo-Saxon, and the Danish settlements. The maps indicate that many broadland areas previously open in the Anglo-Saxon period were occupied by the Danish settlements. This apparently accounts for the high population density given by Domesday statistics. Finally, a stratigraphic section exposed by the construction of a generating station on the spit south of Yarmouth and other excavations made in the Yarmouth area clearly indicate that much of the area was well above sea level at that time. At the Yarmouth site a bed of beach sand and shingle was found 17½ feet below the present sea level; in places mussel shells were found at the top of this bed. The authors are able to show that emergence of the land had begun by A.D. 600. The stratigraphic and historical evidence had shown that peat-digging took place during the period of emergence which ended early in the 13th century. This information, combined with the archeological evidence, made it clear that the basins were dug after the arrival of the Danes (about A.D. 900) and that the broads originated with the beginning of inundation and the close of the era of peat production. The authors point out that the recent origin of the broads necessitates a rapid rate of sedimentation in the basins inasmuch as many are now filled with deposits and some are known to have filled many years ago. They also note that the rates required are in excess of those customarily reported for lakes.

This poor recounting of the bare bones of the mystery is given here only because I hope to illustrate some of the diverse kinds of observations and facts which are skillfully woven together in this study. Beginning with a delightful preface by Professor Godwin, of Cambridge, the monograph is closely reasoned and written. Judicious handling of the mass of detailed observations is one of its striking characteristics. Although interdisciplinary research has become a cliche, this study is recommended to those who have forgotten or who wish to see again what the real article looks like. Send for your copy.

M. GORDON WOLMAN
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Our Developing World. L. Dudley Stamp. Faber and Faber, London, 1960. 188 pp. Illus. 21s.

The central problem facing the diverse societies of this earth now, and for at least the next few decades, is the development and maintenance of levels of living which provide food and shelter adequate for the reasonable health of a rapidly expanding world population. To the layman in Anglo-America, Europe, and a few outliers elsewhere, this does not appear as a troublesome problem because adequate food supplies have been attained. The peoples of the well-fed areas constitute a minority of the world's population and probably a decreasing percentage of the total. In most of the rest of the world, nutritional levels are not sufficient and the prospects for future improvement are uncertain.

It is to this problem that Dudley Stamp addresses himself, and for the second time. In his earlier venture, *Our Underdeveloped World* (1953), his thesis was that the really underdeveloped lands, those susceptible to increased productivity given inputs of known techniques, were located in the mid-latitudes rather than in the tropics. He found the United States to be one of the underdeveloped countries. It was a novel thesis which helped to clarify our thinking about the nature of development.

In *Our Developing World* Stamp reexamines the problem in view of the changes in population and technology which have occurred since the early 1950's and makes use of the data which have become available since that time.

The immediate nature of the problem is indicated by a quote that Stamp uses from *The Future Growth of World Population* [U.N. Population Studies No. 28 (1958)]: "It took 200,000 years for the world's human population to reach 2,500 million, it will now take a mere 30 years to add another 2,000 million." Simplistic arguments of birth control or antibirth control dogmas to one side, societies in a world with nearly twice the present population must have drastically altered technology and social organization if they are to function. And the transition must be rapid. Here is the fascination for the social scientist.

Stamp discusses the changes in agricultural resources needed to enable societies of the world to keep pace with the population explosion. He finds that the habitable world is already inhabited, though with varying degrees of effectiveness in terms of food production. The two large areas of the world which at present make little contribution are the tropical regions of South America and Africa. We do not yet have the technological means for making these areas productive on other than a bare subsistence basis. Active research to this end is underway. (It is deplorable that the promising developments in the study of land use in the Congo have been arrested—and are likely to be lost—by the present disorganization in that territory.) Problems of tropical land use are noted briefly and with insights that reflect Stamp's considerable experience in Burma and Nigeria. The argument here is that tropical land conditions are so different from those of the mid-latitudes that both the local physical and cultural background must be studied before meaningful development can be undertaken. Mechanization, so useful in the mid-latitudes, has proved to be largely unsuccessful in the tropical lands. The probability is not that mechanization itself is unsuitable but that suitable techniques have yet to be developed.

The techniques of the Western World's agricultural revolution, which has taken place largely in the United States, and most drastically since 1950, are discussed in terms of their application in the underdeveloped countries. The heavy use of fertilizers on tillage crops, the potential use of soil structure conditioners, spray irrigation, and the use of antibiotics in livestock feed are all considered with respect to their obvious effects on yield and to the often awkward aspects of their use. Stamp concludes that by a modest diffusion of existing techniques we could feed several times our present population. The problem of diffusion is of course more difficult than the development of techniques.

Stamp states the need for an inventory of existing land resources and suggests a system of land classification to facilitate the inventory.

Further sections are on energy, water, and mineral resources. They are somewhat general and have been handled elsewhere in more analytical fashion by Ayres and Scarlot (1952), Harrison Brown (1955), and Bruce Netschert (1958).

Stamp concludes with several chapters on the relationships between the developed and the underdeveloped countries within the world exchange economy. He notes that many of the impoverished countries have little to offer on world markets that the developed countries cannot better supply for themselves and that attempts to increase the prosperity of these poor countries are therefore severely impeded. Stamp seems to feel that the United States is the main villain; he points out that this country raises severe barriers to imports from the underdeveloped countries and then offers these same countries massive aid which is resented. There are further comments on the less happy aspects of the behavior of American firms and American personnel abroad. The problem of the relationships between the developed and underdeveloped countries has been treated from a different viewpoint by Gunnar Myrdal in *Rich Lands and Poor, the Road to World Prosperity* (1958).

Malthus was one of the first to analyze the problem of world population and food supplies. Stamp is the latest. *Our Developing World* is very good in its treatment of land, population, and agricultural resources, less so in its treatment of energy and mineral resources. It is written not for the specialist in population or agriculture but for the layman and the specialist in other fields who lacks background on this most urgent of problems.

WALTER DESHLER
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Principles of Mineralogy. William H. Dennen. Ronald, New York, 1959. v + 429 pp. Illus. $7.50.

During this last year there has been a rash of new textbooks and new editions of old established works on mineralogy. These include, in addition to the book here reviewed, the following: *Mineralogy* by Kraus, Hunt, and Ramsdell (McGraw-Hill, New York, ed. 5, 1959); *Dana's Manual of Mineralogy* by C. S. Hurlbut, Jr. (Wiley, New York, ed. 17, 1959); and *Mineralogy, Concepts, Descriptions, Determinations* by E. G. Berry and Brian Mason (Freeman, San Francisco, 1959). Recently it was announced that a fifth volume would be published: "Elements of Crystallography and Mineralogy" by F. Alton Wade and Richard B. Mattox. Of the first four, two are essentially traditional in their approach (the two revised editions), but the other two contain numerous innovations of treatment and organization.

This volume by Dennen is divided into two parts: part 1, "General principles," and part 2, "Mineral descriptions." It contains no identification tables but has mineral and subject indexes. Part 1 begins with a chapter on symmetry; in essence, it is a chapter on crystallography, but it lacks many of the standard features. It does not deal with such subjects as the representation of crystals by projections or the determination of crystal faces by means of goniometry. Chapter 2, entitled "Fundamentals of crystal chemistry," considers the architecture of atoms (including nuclear progression, electronic cloud, and quantum states), periodic classification, intrinsic atomic properties, bonds and bonding, and the size and shape of atoms and ions. In chapter 3, which is vaguely entitled "Mineralogical relations," Dennen discusses chemical variation in series and groups and geometrical variations (polymorphs, twinning, and crystal imperfections). In "The physical characteristics of minerals" (chapter 4) he describes not only the several physical and optical properties of minerals but also includes a section on electrical, magnetic, and thermal properties as well as a discussion of crystal growth and habit.

Most of the standard chemical tests for the important elements as well as a discussion of the use of the blowpipe are presented in chapter 5; on page 154 of this chapter there is an extraordinary illustration—a line drawing of a student using the blowpipe as seen from a point directly overhead. Such topics as classification of matter, number and abundance of minerals, mineral classification, and mineral interrelationships are discussed in chapter 6. Emphasis here is on the description of the structures of the ionic species, with a great many drawings of crystal structures.

Part 2, involving mineral descriptions, has but one chapter. The breakdown is by the conventional system of classification: native elements, sulfides, sulfosalts, halides, oxides, hydroxides, oxygen salts (8 subdivisions), and finally silicates. Each species is described under the following headings: crystallography, structure, habit; physical properties; distinctive properties and tests; association and occurrence; alteration; confused with; variance; and related minerals. Some 150 species are described; yet the mineral index lists approximately 600 mineral names. Although most of the names are to be found in the section on mineral descriptions, they are mentioned but briefly as minerals related in various ways to those described in greater detail. There are no drawings of crystals and no photographs of specimens. The section does include representations of the structures of some of the species and a few reproductions of pencil drawings of crystalline groups or crystals. The lack of significant illustrations and the omission of reference to specific deposits, classical or economic, represents a most unfortunate feature, because this tends to impart a degree of abstractness or unreality to the mineral descriptions.

The book, which is "intended for an introductory college course in mineralogy," may serve well as a text for such a course intended for embryonic physicists, chemists, and crystallographers, but it seems inappropriately organized to interest and stimulate beginning mineralogists and geologists.

E. WM. HEINRICH
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Les Mekhadma. Etude sur l'évolution d'un groupe humain dans le Sahara moderne. Arts et Métiers Graphiques, Paris, 1960. 224 pp. Illus. + maps.

Les Mekhadma is a study of a largely sedentary (though formerly pastoral nomadic) Arab tribe caught up in the whirl of the Saharan oil boom. The study is devoted mainly to descriptions of experiments carried out by a team of specialists from PROHUZA (Centre d'Etudes et d'Informations des Problèmes Humains dans les Zones Arides). The experiments involved a great variety of procedures designed to select, mainly by psychometric means, the most able local candidates for employment in an oil field. Also included are a brief history of the Mekhadma, a summary description of their culture, and a rough sketch of the adult male physical type.

The primary objectives of the project were to develop aptitude tests applicable to Saharan native laborers and to learn enough about Mekhadma culture to be able to counteract, at least to some extent, the disruptive effects of sudden and violent contact with European oil-field culture. Therefore, the sociological and psychological sections are slanted strongly by economic emphasis, and they reveal very little concerning either personality or culture beyond those elements whose practical importance seemed obvious to the investigators.

It is regrettable that the authors could not present more information concerning social and political structures, physical anthropology, and health and disease among the community as a whole. But this was not entirely their fault. On the one hand, they were feeling their way in the semidarkness of an almost completely new field of investigation, and they prudently avoided biting off at the start more than they could reasonably expect to chew; on the other hand, their professional enthusiasm was strictly channeled by their commercially minded paymasters. Nevertheless they managed to collect a good deal more information than was published, and their picture of the Mekhadma can be improved considerably if funds for publication are made available.

In spite of its obviously serious shortcomings, *Les Mekhadma* is an important book; for it describes for the first time, in vivid colors and in minute and full detail, the over-all material effect of the shattering collision of a Saharan native culture with the explosive force of European industrial expansion.

This book is extremely valuable within the limits I have indicated; its presentation is luxurious and the photographs are magnificent. It is the first thing of its kind, and it could not be more timely.

LLOYD CABOT BRIGGS
Peabody Museum, Harvard University

The Correspondence of Isaac Newton. vol. 2. 1676–1687. H. W. Turnbull, Ed. Cambridge University Press, New York, 1960. xiii + 552 pp. Illus. + plates. $25.

In the first volume of this monumental, long-awaited edition, we were presented with the juvenile Newton, blossoming into the ingenious optical experimenter, known (but none too widely) to his coterie within the Royal Society. Now, in the second volume, emerges the masterful mathematician, vying with Leibnitz over problems in their new methods of analysis and culminating his achievements with the greatest scientific book ever written, the *Principia Mathematica.*

Out of 162 letters (and manuscripts) here edited, some 66 are published for the first time and many others only now are printed in full and accurate versions. Even more than in the previous volume, the critical notes represent an editorial *tour de force* on which many generations of scholars will be able to lean.

Still, however, even at the height of his powers, Newton proves a disenchantingly impersonal correspondent, so that it comes almost as a warming refreshment when one or another of those writing to Newton goes beyond the bounds of strict scientific intelligencing. Amongst these, American readers should be especially interested to see for the first time the letters of Arthur Storer. Storer's father was a tenant of the Newtons at Woolsthorpe in Lincolnshire, and after some astronomical correspondence with Newton in 1678, Storer traveled to Maryland in the autumn of that year and, though lying sick there for some time, continued to write back news of observations and comets during the years 1681 to 1683.

The editing is so accurate that it is perhaps mete for a reviewer to swoop upon even minor errors. The letters between Gilbert Clerke and Newton (numbers 312 to 316) are said to be in possession of the Burndy Library, New York; however, that rich and most helpful institution is in Norwalk, Conn. On another matter concerned with the possession of manuscripts, it may not be altogether improper to remark that it seems a considerable scholarly annoyance to have some letter printed with merely the superscription "in private possession." It is, to be true, far better than not having the thing at all, but why, let us ask plaintively, must owners be so narrowly possessive or secretive that they will not tell us where to go to see the original?

In my review of the first volume [*Science* **131**, 1202 (1960)] I remarked that this set was to be one of our most valuable and cherished sources in the history of science. Now, with a pair of the volumes on the shelves, that high promise is evidently fulfilled, and I wait all the more eagerly for the rest of the set and for all the other Newton publications now to be unleashed.

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Miscellaneous Publications

(Inquiries concerning these publications should be addressed, not to Science, but to the publisher or agency sponsoring the publication.)

American Fisheries Society. Committee on Names of Fishes. *A List of Common and Scientific Names of Fishes from the United States and Canada.* American Fisheries Society, Ann Arbor, Mich., ed. 2, 1960 (order from Secretary-Treasurer, American Fisheries Soc., Box 483, McLean, Va.). 102 pp. Paper, $1; cloth, $2.

Associação Portuguesa para o Progresso das Ciências. *Congresso Luso-Espanhol,* vol. 23. Celebrado na Cidade Coimbra de 1 a 5 de Junho de 1956. vol. 5, 4a, *Ciências Naturais;* 1a, *Mineralogia e Geologia;* 2a, *Botânica.* 528 pp. 3a, *Zoologia e Antropologia.* 176 pp. vol. 6, 5a, *Ciências Sociais.* 215 pp. vol. 8, 7a, *Ciências Históricas e Filólogicas.* 601 pp. vol. 9, 8a, *Ciências Médicas e Biólogicas.* 648 pp. vol. 10, 9a *Engenharia, Arquitectura e Outras Ciências Aplicadas.* The Association, Coimbra, Portugal, 1956–57.

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Australia. Division of Land Research and Regional Survey. *Technical Paper,* No. 8, "The establishment of pasture species on arable land at Katherine, N.T.," M. J. T. Norman, 18 pp.; No. 9, "Performance of annual fodder crops at Katherine, N.T.," M. J. T. Norman and R. Wetselaar, 16 pp.; No. 10, "Soil and crop nitrogen at Katherine, N.T.," R. Wetselaar and M. J. T. Norman, 18 pp.; No. 11, "Performance of buffel grass and buffel grass-townsville lucerne mixtures at Katherine, N.T.," M. J. T. Norman, 14 pp. *Soil Publication,* No. 16, "The development and distribution of the soils of the Swan Coastal Plain, Western Australia," W. M. McArthur and E. Bettenay. Commonwealth Scientific and Industrial Research Organization, Melbourne, 1960.

British Museum (Natural History), London. *Bulletin.* Botany, vol. 2, No. 7, "The identity of *Isopyrum aquilegioides* L., Gavin de Beer and William T. Stearn. 10 pp. 6s. Entomology, vol. 9, No. 3, "Sphecidae (Hym.) Recoltes en Tripolitaine et en Cyrenaique par M. Kenneth M. Guichard." 52 pp. 12s. Geology, vol. 4, No. 5, "A review of the Upper Jurassic Pliosaurs." Lambert Beverly Tarlo. 45 pp. 24s. The Museum, London, 1960.

Chicago Natural History Museum. *Fieldiana: Botany,* vol. 30, No. 3, "Orchids of Peru," Charles Schweinfurth, 253 pp., $4.50. *Geology,* vol. 11, No. 10, "Fishes of the Devonian Holland Quarry shale of Ohio," Robert H. Denison, 60 pp., $1.50. *Geology,* vol. 14, No. 1, "The stratigraphy of the Devonian Holland Quarry shale of Ohio," J. Ernest Carman, 5 pp., $0.15. *Zoology,* vol. 39, No. 35, "Two eels of the genus *Synaphobranchus* from the Gulf of Mexico," P. H. J. Castle, 12 pp., $0.30. *Zoology,* vol. 39, No. 36, "A new genus of blind beetles from a cave in South Africa," Henry S. Dybas, 6 pp., $0.20. *Zoology,* vol. 41, No. 2, "Birds of Gabon and Moyen Congo," Austin L. Rand, Herbert Friedmann, and Melvin A. Taylor, Jr., 218 pp. Chicago Natural History Museum, Chicago, Ill., 1960.

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Reports

Isolation, Identification, and Synthesis of the Sex Attractant of Gypsy Moth

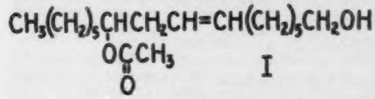
Abstract. The extremely potent sex attractant of the female gypsy moth has been isolated in pure form and identified as dextrorotatory 10-acetoxy-1-hydroxy-*cis*-7-hexadecene. The *dl*-form of the attractant has been synthesized.

For almost 30 years, investigators at the Department of Agriculture have been trying to isolate and characterize the substance secreted by the female gypsy moth (*Porthetria dispar* L.) and used to lure the male for purposes of mating (*1*). A crude extract containing this attractant is used on a large scale in survey traps to locate areas infested with this destructive pest of forest and shade trees (*2*). We now wish to report the successful isolation, identification, and synthesis of the pure, extremely potent attractant.

The benzene extractive prepared from the last two abdominal segments of 500,000 virgin female gypsy moths (*3*) was saponified with boiling ethanolic alkali, the neutral fraction was dissolved in acetone, and the solid that separated at room temperature, at 5°C, and at −5°C was filtered off and washed with a little cold acetone. Evaporation of the acetone filtrate gave 75 mg of a pale yellow, viscous oil highly attractive to male moths in bioassay and field tests (*4*). Reverse-phase chromatography of the active oil by the ascending technique on silicone- or 30 percent polyethylene-impregnated Whatman No. 1 filter paper sheets with methanol-benzene-water (5:1:1) as solvent gave five spots (as previously determined by spraying a sample chromatogram with Sudan Black), only one of which (R_F 0.0) was attractive. This zone was cut out and extracted repeatedly with cold 95 percent ethanol and then with petroleum ether (hexane). In this way there were obtained 3.4 mg of white waxy crystals soluble in ethanol and 20 mg of colorless, blue-fluorescing, petroleum ether-soluble liquid that solidified in the cold but remelted at room temperature. The latter was attractive to males in field tests in quantities less than 10^{-7} μg; the waxy solid was approximately 25 percent as active.

Gas chromatography of the liquid attractant on Craig polyester succinate showed it to be a pure material, which analyzed most closely for $C_{17}H_{32}O_3$ or $C_{18}H_{34}O_3$. Its infrared spectrum showed the presence of primary hydroxyl, secondary acetoxyl, an unbroken chain of at least four methylene groups, and a probable *cis* double bond; aromatic rings, *trans* unsaturation, acetylenic bonds, and branched methyl groups were absent. The attractant was optically active, $[\alpha]_D^{28} + 7.9°C$ (*c*, 1.0; $CHCl_3$). Catalytic hydrogenation of 2 mg of the attractant with platinum oxide catalyst resulted in an uptake of hydrogen sufficient for almost exactly one double bond, giving an oil whose infrared spectrum indicated complete saturation; it was one-third as attractive to male moths as the natural attractant. Saponification of 1.8 mg of the saturated compound required refluxing with diethylene glycol-potassium hydroxide mixture at 120°C for 3 minutes, showing a saponification equivalent of 314 and yielding 1.45 mg of an unattractive, crystalline diol and an acid identified by its infrared spectrum as acetic acid. Oxidation of 4 mg of the natural attractant with periodate-permanganate reagent (*5*) gave 2.4 mg (92 percent) of a pale yellow oil identified as 3-acetoxy-1-nonanoic acid [bp 120°C (0.2 mm-Hg); n_D^{25}, 1.4470] and 1.6 mg (83 percent) of a viscous oil which was oxidized with potassium permanganate in acetone to 1.2 mg (71 percent) of colorless crystals, mp 104–105°C, identified as pimelic acid by mixed melting point, infrared spectrum, and paper chromatography with a pure synthetic sample.

The major attractant of the female gypsy moth is therefore (+)-10-acetoxy-1-hydroxy-*cis*-7-hexadecene (I).



The *dl*-form of compound I was synthesized in 0.2 percent over-all yield by the following procedure. Dec-1-yn-4-ol, prepared by condensing *n*-heptaldehyde and propargyl bromide in the presence of zinc (*6*), was converted to its tetrahydropyranyl ether (55 percent; bp, 142° at 0.5 mm; n_D^{25}, 1.4506). Condensation of the sodium derivative of the latter with 1-chloro-5-iodopentane by the method of Taylor and Strong (*7*) gave 1-chloro-9-(tetrahydro-2-pyranyloxy)-pentadec-6-yne (35 percent; bp, 183–185°C at 0.1 mm; n_D^{25}, 1.4753). Refluxing this compound with sodium cyanide in ethanol and hydrolysis of the crude product with alcoholic alkali, followed by removal of the tetrahydropyranyl group with 2*N* sulfuric acid, gave 10-hydroxy-7-hexadecynoic acid in 15 percent yield as colorless crystals, mp 51–52.5°C. Selective hydrogenation of this acid with quinoline-poisoned Lindlar catalyst (*8*) gave 81 percent 10-hydroxy-*cis*-7-hexadecenoic acid, white waxy solid, mp 28–29°C, which was reduced with lithium aluminum hydride to 1,10-dihydroxy-*cis*-7-hexadecene (98 percent), a pale yellow oil. The undistilled diol was converted to the diacetate (75 percent; bp, 172°C at 1.4 mm; n_D^{25}, 1.4525) with acetyl chloride in anhydrous benzene. Refluxing the diacetate with sufficient ethanolic alkali to saponify the primary acetoxyl group gave (±)-I (92 percent) as a colorless liquid, bp 169°C at 0.2 mm, identical in every respect save optical activity with the natural gypsy moth attractant.

The *d*- and *dl*-forms of compound I show approximately the same attractiveness to male gypsy moths in the field. To our knowledge, this is the first reported synthesis of a naturally occurring insect sex attractant.

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Instructions for preparing reports. Begin the report with an abstract of from 45 to 55 words. The abstract should *not* repeat phrases employed in the title. It should work with the title to give the reader a summary of the results presented in the report proper.

Type manuscripts double-spaced and submit one ribbon copy and one carbon copy.

Limit the report proper to the equivalent of 1200 words. This space includes that occupied by illustrative material as well as by the references and notes.

Limit illustrative material to *one* 2-column figure (that is, a figure whose width equals two columns of text) or to *one* 2-column table or to *two* 1-column illustrations, which may consist of two figures or two tables or one of each.

For further details see "Suggestions to Contributors" [*Science* 125, 16 (1957)].

3. Of this total, 200,000 were collected in Connecticut and 300,000 were collected in Spain.
4. Bioassay tests were carried out by the method of B. C. Block [*J. Econ. Entomol.* **53**, 172 (1960)]. Field tests were carried out as described by J. M. Corliss ["Insects," *U.S. Dept. Agr. Yearbook Agr.* (GPO, Washington, D.C., 1952), p. 694]. The assistance of Mr. E. C. Paszek, U.S. Department of Agriculture, Nashua, N.H., in carrying out these tests is gratefully acknowledged.
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6 August 1960

Expanding Shoals in Areas of Wave Refraction

Abstract. Shoals and spits may grow seaward, despite powerful refracted wave attack, where the wave energy level is too low to handle the supply of sand introduced by the littoral drift. Spits and shoals of this type have distinctive shapes. They may support ripple marks which do not parallel the crests of the waves which form them.

Wave refraction around a headland or point results in a concentration of wave energy, and hence a heightened level of activity. This fact is well known. The result is not, however, invariably erosion. Under certain conditions, concentrations of sand may occur, and be maintained, in areas of wave refraction. Such sand masses may appear as points, spits directed seaward, and near-shore shoals.

One requirement is that the coastal energy level be too low to handle the supply of sand (or other detritus) available. It may also be true that the unidirectional energy be essentially zero, as a result of cancellation of the littoral drift vectors.

Shoals, spits, and points of this type may appear on lagoonal shores, where wave energy is generally low, or on open, unprotected beaches. Each shoal commonly consists of several hummocks or faint swells, separated by gentle furrows, all arranged essentially parallel to the shore (see Fig. 1, *E*, for example). Such shoals may be rather large (that is, miles across; see Fig. 1, *A* and *B*) or small (tens or hundreds of feet across; Fig. 1, *C* and *D*).

The examples reported here occur along a coast of zero to moderate energy. This classification is based on a scale on which an average breaker height of 1 to 10 cm indicates low energy, 10 to 50 cm, moderate energy, and more than 50 cm, high energy. The average breaker at Cape San Blas, Fla. (Fig. 1, *A*), is about 13 cm (*1*). The energy level decreases from there toward the east. At Keaton Beach (Fig. 1, *D*), no long-term average is available, but breakers commonly do not form along the beach at all, and much of the time only small ripples, millimeters high, disturb the surface near the water's edge.

The breaker height at Cape San Blas indicates an energy level sufficient to handle (in terms of net littoral drift, past a given point) only about 2.5×10^4 m^3 of sand per year. Over the years, the Apalachicola (that is, Chattahoochee) River has delivered a greater load than that. Hence the large shoal areas at Cape San Blas and Cape St. George (Fig. 1, *B*) are related to the moderate level of coastal energy, coupled with the relatively large available supply of beach and near-shore sand.

Near Bald Point (Fig. 1, *C*) and Keaton Beach the annual accretion of sand is almost negligible, but the energy level is also very low. The small supply of sand is therefore piled into similar spit-and-shoal areas. These smaller features are in no sense beach cusps, although beach cusps commonly form in the same areas. (Beach cusps do not extend, below water, as shoals.)

Fair weather wave refraction patterns, on the smaller shoals, are quite clear (Fig. 1, *F*), and indicate a piling up of sand in these localities. During storms some of this sand is probably moved seaward, only to be worked landward again during the next period of long-term, essentially calm weather. Refraction of the waves produces two apparently dissociated wave sets, which cross each other at acute angles. The ripple marks produced by these two sets are more-or-less regular in general plan, but parallel neither wave set. Instead, they bisect the acute angle between the two sets, and approach an angle of roughly 45° with either set. Ripple marks of this type seem to be characteristic of the smaller shoals, where the water is very shallow (that is, less than 10 ft). Ripple marks on the larger shoals, which occur in deeper water, are of the more conventional types.

In some instances large shoal areas may result from an abundance of river sediment (as in Fig. 1); in others, a similar pattern may be due to decreasing energy, in the down drift direction (for example, the shoals off of Cape Hatteras, Cape Lookout, and Cape Fear, N.C., where the average breaker heights are about 85 cm, 75 cm, and perhaps 55 cm, respectively).

Sand concentrations of the variety described here are indications that the locality studied either now has, or recently has had, a supply of sand greater than that required by the prevailing wave energy level. The beach at such points must be, in general, either stable in position or prograding. This inter-

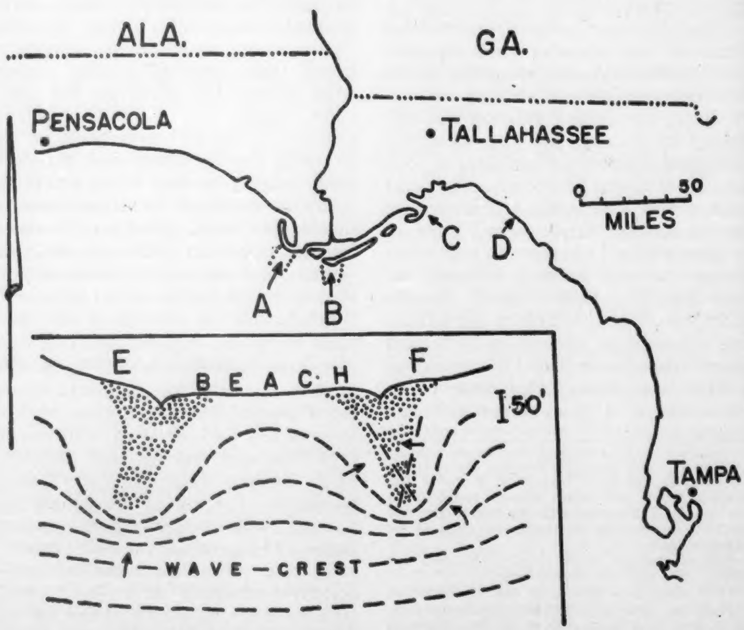

Fig. 1. Map of the Apalachicola River delta and adjacent parts of Florida, showing the location of shoals where available littoral materials are excessive, in the light of the current wave energy levels. Large shoals occur at Cape San Blas (*A*) and Cape St. George (*B*); many small shoals, closely spaced, occur at *C* and *D*. Inset: diagram showing details of two typical small shoals, with wave refraction patterns, such as those near *C*.

pretation should be made, regardless of temporary effects such as those produced by a hurricane.

There is, however, no indication as to the absolute amount of sand available for littoral drift, nor for the absolute energy level. Examples of these "overload" shoals can be seen along areas of essentially zero energy, low energy, moderate energy, and high energy. In each case it is necessary only that the supply of sand along the beach exceed the amount which would normally be moved, in view of the wave energy level.

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14 March 1960

Delayed Visual Feedback and Behavior

Abstract. By means of video-tape recording the visual presentation of a person's behavior, as he carries out some task, can be delayed in such a way that the individual sees what he is doing a short time after he has done it. The effects of this delay of visual feedback on a variety of simple visual-motor tasks are found to be both marked and deleterious, and in some respects similar to the effects of delayed auditory feedback on speech and motor tasks.

In the same way that the sound of a subject's voice can be stored momentarily on magnetic tape and played back during the course of speech (*1*), it is possible, through the use of newly developed video-tape recording and reproducing equipment, to store and play back the visual representation of a subject's performance field in such a way that the subject observes a televised display of his behavior shortly after the behavior has occurred. In this report we describe the results of some preliminary observations concerning the effects of such visual delay on a sample of visual-motor tasks.

The RCA laboratory magnetic tape video recording and reproducing system was used to produce delayed vision (*2*). The subject sat in front of a television monitor (21-in. screen) which received the output of a second playback unit. A delay of approximately 520 msec was provided. In order to prevent the subject from seeing the task area directly, a pair of special goggles was used. An RCA miniature television camera was located at eye level and next to the subject's head to minimize angular distortion of the televised performance field. Magnification of the performance field was approximately 1.5.

The subject carried out various tasks on the electronic handwriting analyzer, a device described by Smith and Bloom (*3*), which permits the measurement of both manipulative and travel components of writing or similar motions. The subject observed on the television screen a portion of the writing surface of this device, together with his hand with the pencil in it and a part of his forearm.

The nine different tasks listed in Table 1 were performed by two subjects under three conditions of observation; television-delay, television-no delay, normal (ordinary observation). Tasks, as well as sequences of words and syllables, were randomly assigned to each subject. Comparisons among the three conditions suffer from the lack of control for practice, in that the observations with delay were obtained 2 weeks prior to those obtained under the no-delay conditions, but in view of the magnitude and nature of the observed differences and the nature of the tasks themselves, not much significance is attached to the possible effects of practice from condition to condition. Instructions in all three cases were to perform the task as accurately and as rapidly as possibile (and as neatly as possible in the case of writing tasks).

The first thing to be said about the effect on behavior of delayed visual feedback as revealed in these observations is that performance becomes inordinately difficult and frustrating. It is nearly impossible to perform the simplest of tasks, such as placing a dot in the center of a circle, with any reasonable degree of accuracy. Any localizing movement, in fact, demands great effort, and little accuracy is obtained. What normally would be fast, smooth, placing motions become erratic and oscillatory movements which assume a characteristic jerkiness. Handwriting, even of very familiar material, becomes severely degraded and in some cases completely illegible. In Fig. 1 are reproduced some of the original records showing samples of star tracings, drawings of simple geometrical figures, maze tracings, and handwriting. Specimens from the records of the two no-delay conditions are given for purposes of comparison.

An error analysis of the writing material reveals that, in addition to the obvious degradation of legibility, particular kinds of errors occur. The most frequent kind of error in a total of 64 errors was letter duplication (40.6 percent), examples of which can be seen in Fig. 1, *D* and *E*. The predominance of this type of error parallels the findings of the Bergeijk and David study (*4*) and agrees with the results on articulatory errors found in delayed auditory feedback.
most frequent kind of error found in our observations was error of insertion —that is, the occurrence within a word of letters or part letters which did not belong there (26.6 percent). There were a few errors of omission (7.8 percent), one error of substitution, and a variety of miscellaneous errors (23.4 percent). The relatively frequent occurrence of errors of duplication and insertion might be considered "graphic stammering and stuttering," analogous to the articulatory effects in speech due to delayed auditory feedback.

Evaluation of the accuracy of performance of the nonwriting tasks shows more dramatically the effects of delayed vision. In the star- and maze-tracing tasks some of the records were so bad that they were literally unscorable. The star record in Fig. 1 is the best example of this extreme degree of degraded performance. There was, however, an obvious improvement in these two tasks over the few trials performed by each subject. An interesting question for future investigation is the degree of improvement obtainable in such tasks with extended practice.

In addition to the low quality and low accuracy of performance produced by the delayed visual feedback, very marked effects on temporal characteristics of performance were found. Table 1 summarizes the time data for the two

Table 1. Manipulation or contact time for the various visual-motor tasks for each subject under the three conditions of observation. All values are means in seconds. Data on two tasks under the television-delay condition were not obtained for subject B.

Subject	Time (sec) TV delay	TV no-delay	Normal
	Writing letters of alphabet		
A	2.0	0.6	0.6
B	1.2	0.7	0.5
	Star-tracing		
A	86.2	13.8	5.9
B	49.6	16.0	6.3
	Drawing 3 geometric figures		
A	6.1	3.5	3.5
B	5.0	6.4	4.7
	Writing 4-letter nonsense syllables		
A	4.8	4.1	2.0
B	6.4	2.4	1.9
	Writing 4-letter words		
A	4.3	1.7	1.5
B		2.6	1.6
	Maze-tracing		
A	102.8	18.0	7.2
B	107.6	23.9	7.6
	Writing Bergeijk-David words		
A	5.9	2.5	2.2
B	5.5	3.1	2.4
	Writing 3-letter nonsense syllables		
A	5.1	1.7	1.4
B		2.2	1.6
	Placing dots in 6 circles		
A	27.8	2.8	2.5
B	12.7	4.0	1.7

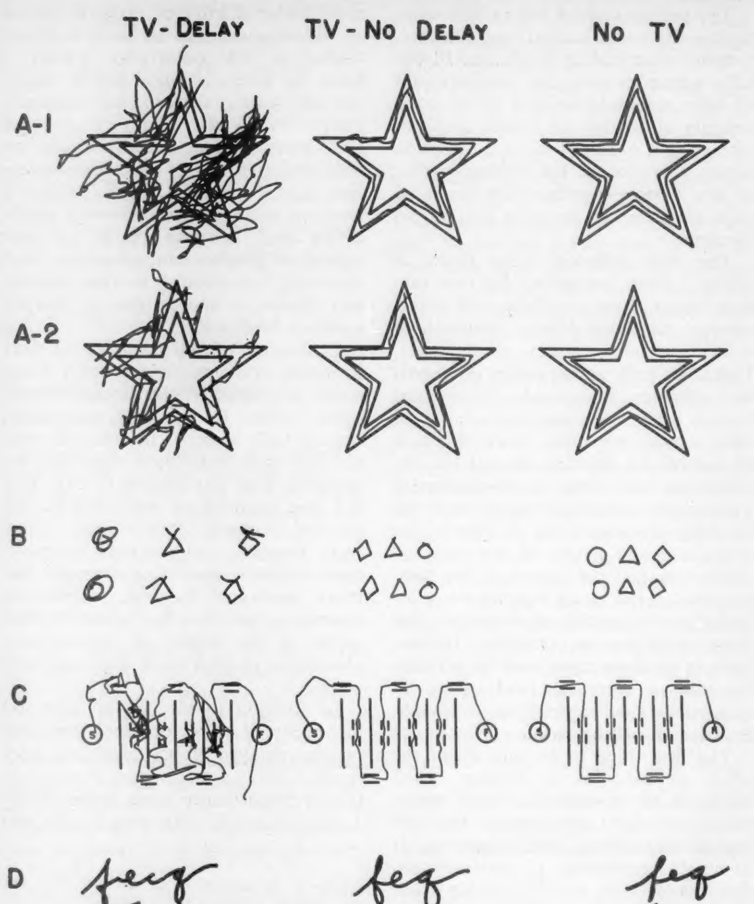

Fig. 1. Sample records for some of the tasks performed under delayed visual feedback.

subjects on all tasks for the three different conditions. The measures in this table represent the contact or manipulative time (the actual time the subject had the metal pencil touching the writing surface) expressed as means. As the table shows, some tasks required a tenfold or greater increase in time for completion, in comparison to the normal or television no-delay condition. Although not shown in the table, the separate measures of travel time (time the metal pencil was off the writing surface during the execution of writing movements, dotting circles, and so forth) provide similar results—namely, consistent and marked increases in time for the delayed condition in comparison to the other two.

These results clearly emphasize the critical importance of the temporal aspects of visual feedback in the control and regulation of human performance. They are, in addition, in general agreement with the results of an unpublished study on simulated delayed visual feedback (*5*), with the results of the investigation of delayed handwriting by Bergeijk and David (*4*), and with studies on the effect of delayed auditory feedback on speech, tapping, and other motor performances (*1*, *6*). Delayed auditory or visual feedback seriously degrades performance, introduces characteristic redundant motions, increases performance time by marked amounts, and imposes upon the subject very difficult and frustrating conditions.

We believe that the technical achievement of video-tape recording places in the hands of investigators a very significant technique for the future study of human perception and motion.

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15 July 1960

Effect of Galactose-1-Phosphate on Glucose Oxidation by Normal and Galactosemic Leukocytes

Abstract. During incubation with galactose, galactosemic leukocytes accumulated more galactose-1-phosphate than did normal leukocytes. Concomitant determination of glucose oxidation, with C^{14} glucose, revealed no inhibition of the hexosemonophosphate pathway. These results are at variance with recent studies in rat lens tissue, which suggests that intracellular galactose-1-phosphate depressed glucose-6-phosphate dehydrogenase activity and the oxidative pathway.

Studies by Kalckar and his associates (*1*) have established that patients with congenital galactosemia are deficient in the enzyme galactose-1-phosphate uridyl transferase. This deficiency results in an inability to utilize dietary galactose, but endogenous synthesis of essential galactose-containing substances continues normally via uridine diphosphoglucose and uridine diphosphogalactose-4-epimerase. Since the clinical manifestations of galactosemia are related to dietary galactose, investigators have sought to explain the toxic features of the disease through the direct or indirect effects of galactose or α-D-galactose-1-phosphate (Gal-1-P), the two compounds that accumulate as a result of the metabolic block.

In 1956 Schwarz and his associates (*2*) found increased levels of Gal-1-P and diminished uptake of O_2 in galactosemic red blood cells. They also reported an accumulation of this ester in the cataractous lenses of rats fed a high-galactose diet, and they suggested that Gal-1-P interferes with glucose metabolism, this interference resulting in the toxic features of the disease (*3*). Lerman (*4*) has recently reported that in the galactose cataracts of rats there is a significant inhibition of glucose-6-phosphate (G-6-P) dehydrogenase and a resultant stunting of glucose metabolism via the hexosemonophosphate pathway. He has postulated that since this pathway is a principal source for glucose utilization in lens (*5*), inhibition by Gal-1-P may explain the cataracts in the experimental animal and galactosemic patient. Because human leukocytes have abundant G-6-P dehydrogenase (*6*) and an active hexosemonophosphate pathway (*7*), metabolize galactose and glucose readily in vitro (*8*), and are easily obtained from normal and galactosemic subjects, they provide an excellent experimental model to test for inhibition of the hexosemonophosphate pathway by Gal-1-P.

In the studies described below, leukocytes were obtained by fibrinogen sedimentation, as described by Skoog and Beck (*9*). Aliquots of the leukocyte suspension containing 2 to 3 × 10^7 cells were preincubated in modified Warburg flasks for 1 hour with glucose and galactose, as indicated in Table 1. Glucose-1-C^{14} or glucose-6-C^{14} (0.45 μc in 20 μl) was then added to alternate flasks, and the incubation was continued for an additional hour. The reaction was stopped with acid, and the $C^{14}O_2$ was trapped in 1 ml of hyamine base, added to the center well, and then transferred to a vial and counted in a TriCarb liquid scintillation counter (counting efficiency 50 percent). A ratio greater than unity for the amount of $C^{14}O_2$ derived from glucose-1-C^{14} as compared to that from glucose-6-C^{14} has been taken as evidence for the presence of the hexosemonophosphate shunt in the tissue under study (*10*). In each experiment an additional flask containing leukocytes and 50 mg of glucose and 100 mg of galactose per 100 ml was incubated for 2 hours, and the accumulated intracellular Gal-1-P was determined by the enzymatic method of Kirkman and Maxwell (*11*), after the centrifuged cells had been washed with normal saline and broken in a sonic oscillator.

Table 1 contains the results of these studies on four normal subjects and four patients with congenital galactosemia. The accumulation of Gal-1-P was significantly greater in the galactosemic cells, averaging 10.6 μg per 2 × 10^7 cells, as compared to 2.6 μg for an equal number of normal cells. The ratios of $C^{14}O_2$ from C^1- and C^6-labeled glucose did not change appreciably in either group, a finding that suggests that under the conditions of these experiments there was no inhibition of glucose oxidation via the hexosemonophosphate pathway. When galactose was present as a substrate there was slight lowering of counts from both C^1- and C^6-labeled glucose. From results of other studies involving C^{14}-labeled galactose or glucose incubated with unlabeled glucose or galactose, respectively, we have assumed that the decreased counts are due to dilution of the specific activity of the CO_2 pool and/or competition between the hexoses for membrane transport or phosphorylation with available adenosine triphosphate (*12*).

Table 1. Production of $C^{14}O_2$ and accumulation of galactose-1-phosphate in normal and galactosemic leukocytes. The 2-hour incubations were at 37°C in a Dubnoff shaker, in an atmosphere of 95 percent O_2 and 5 percent CO_2. Each counting is the average for triplicate flasks containing 5 ml of leukocyte suspension plus 1.5 ml of Krebs-Ringer bicarbonate buffer with added sugars as indicated. The C^{14}-labeled glucose was added after 1 hour.

Subject	Gal concn.* (mg/100 ml)	$C^{14}O_2$ [count/min (2 × 10^7 white cells)] Substrate: Gluc.-1-C^{14}	Substrate: Gluc.-6-C^{14}	C^1/C^6	Gal-1-P accumulation (μg/2 × 10^7 white cells)	(mg/100 g)†
		Galactosemic				
T.B.	0	1590	76	21		79
T.B.	100	1274	64	20	9.5	
M.O.D.	0	891	50	18		95
M.O.D.	100	984	42	23	11.3	
P.R.	0	1010	26	39		106
P.R.	100	815	22	36	12.7	
E.W.	0	2095	58	36		73
E.W.	100	1690	46	37	8.8	
		Normal				
J.C.	0	882	50	18		39
J.C.	100	666	43	16	4.7	
A.W.	0	1362	58	23		15
A.W.	100	1156	65	18	1.8	
S.S.	0	507	25	20		32
S.S.	100	494	19	26	3.9	
C.S.	0	1120	38	40		0
C.S.	100	1022	25	41	0	

* Glucose concentration, 50 mg/100 ml in each flask. † Based on net weight of 10^7 white blood cells=6 mg (*13*). Reported data on Gal-1-P in lens tissue are expressed in mg/100 g (*3*).

Using normal and galactosemic human leukocytes in the present study, we were unable to find a specific inhibition of glucose oxidation via the hexosemonophosphate pathway under conditions where there was a considerably greater accumulation of Gal-1-P than was recorded in experiments in which lenses from galactose-fed rats were used. From our data obtained in leukocytes it cannot be concluded that glucose metabolism in other tissues is unaltered by the presence of Gal-1-P. The present observations indicate that the accumulation of this sugar phosphate in galactosemic tissue is not necessarily associated with inhibition of the oxidative pathway of glucose metabolism.

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6 June 1960

Molybdenum as a Factor Limiting Primary Productivity in Castle Lake, California

Abstract. A trace-element deficiency is evident from carbon-14 bioassays of Castle Lake's natural phytoplankton populations. Increase in photosynthetic rates with the addition of molybdic acid or sodium molybdate has been demonstrated throughout the year. It is likely that other trace elements may also be found to be limiting factors in lakes having a limited watershed.

A study of primary productivity and limiting factors in a number of northern California lakes was started in March 1959. Castle Lake was among the lakes selected for this study. It is in a cirque basin at an elevation of 5200 feet in the Klamath Mountains, 11 miles southwest of Mt. Shasta, California. Its surface area is 19.4 hectares, and the lake has a maximum depth of 36.5 m. Studies on trout production in the lake have been in progress since 1938 (*1*).

A rapid carbon-14 bioassay technique developed for limiting-factor investigations in Alaskan lakes in 1957 (*2*) revealed changes in photosynthetic rate under various nutrient conditions. The lake's natural, unconcentrated phytoplankton population was studied under both field and laboratory conditions. Cultures in the field were contained in sterile, screw-cap, 500-ml Pyrex erlenmeyer flasks fastened to a floating crib anchored in the lake near shore. This arrangement provided lake-surface conditions of temperature and light and maintained the plankton population in suspension through wave motion of the crib. In the laboratory, cultures were held at a constant (10°C) temperature under a 40-watt fluorescent light.

In June 1959 cultures in both the lake and laboratory showed very significant increase in carbon fixation with the addition of potassium, sulfate, or a trace-element mixture. Subsequent cultures in which trace elements were added separately demonstrated that molybdenum was the stimulating micronutrient. Addition of 0.100 part of molybdenum (as Na_2MoO_4) per million increased the rate of photosynthesis of the lake phytoplankton over a 4-day period in June (Fig. 1). This was accompanied by a high rate of primary productivity in the lake. The addition to cultures of 0.100 part of molybdenum (as molybdic acid) per million had the same effect as the addition of Na_2MoO_4.

Other experiments started throughout the summer, fall, and winter of 1959 gave nearly identical results. Responses early in the season were greater; responses diminished somewhat with the seasonal decline in primary productivity and perhaps with rainfall in August and September. By October, 0.050 part of molybdenum per million was more effective than higher concentrations. In cultures maintained in the lake under 1 m of ice on 10 January 1960, the addition of 0.025 part of molybdenum per million gave a significant response during a 4-hour period. Although an increase in the rate of photosynthesis was consistently evident with the addition of from 0.001 to 0.050 part of molybdenum per million, the optimum was about 0.025. In the early summer of 1960, the addition of 0.005 part per million gave a greater response than higher concentrations.

The essential role of molybdenum in the growth of higher plants has been recognized since 1939 (*3*). It was demonstrated as a requirement for *Chlorella* in 1953 (*4*) and for *Scenedesmus* in 1955 (*5*). The low levels of molybdenum evident in a number of inland waters and the involvement of molybdenum in nitrogen reduction and fixation have suggested its possible importance in lakes (*6*). Although this is the first time molybdenum has been reported to be a limiting factor in lakes, it is probable that it and other micronutrients will be found in limiting concentrations in lakes with restricted watersheds.

The importance of molybdenum in the formation of nitrate reductase and in nitrogen fixation is well established (*7*). In attempting to identify more specifically the factors involved in the

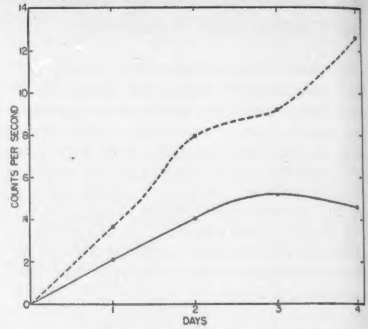

Fig. 1. Stimulation in the rate of carbon fixation (as measured by C^{14} uptake) with the addition of molybdenum to a culture of Castle Lake's natural phytoplankton population maintained at lake-surface temperature and light. Solid line, the control; broken line, the culture with 0.10 part of molybdenum per million added. This experiment was started on 29 June 1959.

molybdenum deficiency in winter, Mo, NH_4^+ and NO_3^- were added singly and in combination. An almost totally nannoplankton population is characteristic of Castle Lake under ice conditions. Lack of response in *in situ* winter cultures with NH_4^+ or NO_3^-, and response to the addition of Mo and NH_4^+ would seem not to favor a reductase requirement. Nitrogen fixation by these microplankton remains a possibility as does a deficiency in more than a single enzyme system.

The alder trees (*Alnus tenuifolia* Nutt) that are abundant along the east shore of Castle Lake make an appreciable nitrogen contribution to the lake, principally in the form of NO_3^- (*8*). Reduction of this nitrate by phytoplankton presumably would require molybdenum, which is in the lake in suboptimal concentrations. Analysis of the alder leaves showed molybdenum to be present in trace quantities (< 0.1 part per million). The nitrogen-fixing alder trees and other plants may be competing with the lake for the available Mo, K^+, and $SO_4^{=}$ which would otherwise be added by the springs draining the alder-covered shore line. Culture experiments carried out during June and July of 1960 showed a lower response to the addition of molybdenum than those of the previous year. Precipitation between March and August of 1959 was only 35 percent of the mean annual precipitation for those months, and thus it seems likely that replenishment of molybdenum by inflow is a critical factor in reducing the level of deficiency (*9*).

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8. C. R. Goldman, in preparation.
9. This work was supported by the National Science Foundation (grant No. G-8901) and the Dingell-Johnson Project, California (F-8-R).

8 August 1960

Simple Technique for Study of Cortical Arousal Response

Abstract. A new method is described for eliciting a stable spindle burst response after the production of unilateral lesions in the reticular formation of the cat. This permits quantifying the effects of stimulation of the reticular activating system, either electrically or by injection of epinephrine, on the cortical arousal response.

The cortical arousal response, produced by either direct or indirect stimulation of the reticular activating system, has been used extensively as a test for drug action since its first description in 1949 (*1*). Unfortunately, unless facilities for elaborate electronic analyses are available, the evaluation of the magnitude and duration of this response is quite subjective. We herein describe a method for quantification of this response in cats by the use of unilateral brain stem lesions which produce a stable ipsilateral cortical spindle burst response. This is abolished during electrical or pharmacological stimulation of the reticular activating system.

Bremer in 1935 (*2*) discovered that transection of the anterior portion of the midbrain (*cerveau isolé*) led to spindle bursts which recurred during several hours. Lindsley *et al.* (*3*) reported on lesions in different areas of the brain stem and demonstrated stable spindle burst activity after mesencephalic and basal diencephalic bilateral lesions.

As an extension of their work we placed complete unilateral electrolytic lesions stereotaxically, using the coordinates described in the atlas of Jasper and Ajmone-Marsan (frontal, 3; horizontal, −2; vertical, 0 to 4) (*4*). The exact frontal placements were not critical for the production of the spindle bursts. There was an indication, however, that the response decayed somewhat more rapidly as the lesion was moved caudad or cephalad.

Surgery was performed under ether anesthesia; the animal was subsequently immobilized with gallamine triethiodide and maintained on artificial respiration and local anesthesia with 1 percent procaine hydrochloride. The animals were in a sound proof room and were kept as comfortable as possible during the recording sessions.

Some experiments were carried out using the *encephale isolé* preparation and, although the burst characteristics and background activity were slower, the response remained as stable as that seen with the immobilized animal. After a 1 hour recovery period, spontaneous electrical activity recorded from the cortex ipsilateral to the lesion showed the spindle burst phenomenon. The rate of bursting varied from 8 to 15 bursts per minute from animal to animal, but was relatively constant for a given animal. A stable response could be maintained for 3 to 4 hours if the animal remained in good condition. The spindle bursts could always be recorded from the suprasylvian and posterior sigmoid gyri and sometimes from the anterior sigmoid gyrus.

Since the contralateral side of the brain stem was intact, electrical or drug stimulation of the reticular activating system could still produce a cortical arousal response. This response was manifested by a disappearance of the spindle burst activity and, in some cases, by an increase in the frequency of the background activity of both sides of the cortex. The duration of the abolishment of the spindle bursts was directly correlated with the strength of the electrical stimulus or the dose of epinephrine, within normal physiological ranges. Figure 1 illustrates the effects of sciatic nerve stimulation and of intravenous epinephrine on the cortical spindle bursts in a cat with a unilateral brain stem lesion.

The disappearance of the spindle bursts lasted throughout the duration of the sciatic stimulation and about 10 to 15 seconds after the end of the stimulation. The rate and frequency of the electrocorticogram on the contralateral cortex seemed to return to prestimulus activity about 4 or 5 seconds after the return of the bursts on the ipsilateral side. Intravenous epinephrine caused the burst response to vanish about 10 seconds after the beginning of the injection (see *5*). The bursts began to reappear about 30 seconds later and sometimes showed a secondary effect of an increased rate for about 10 to 20 seconds before returning to the preinjection rate (*6*).

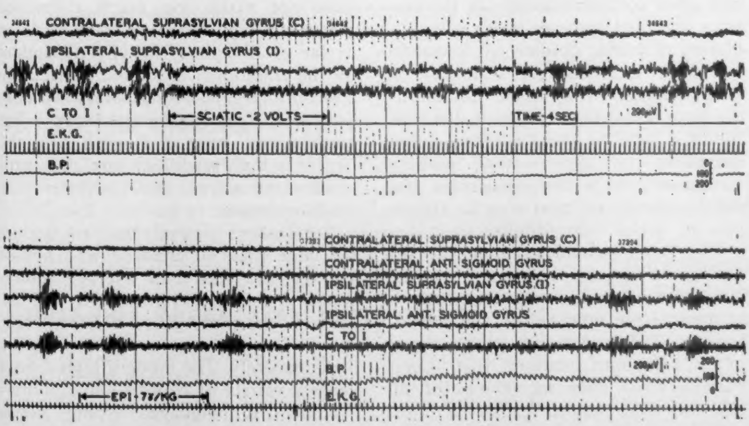

Fig. 1. Effect of sciatic stimulation and intravenous epinephrine on the electrocorticographic spindle burst response of the immobilized cat with a unilateral brain stem lesion. Upper section: Sciatic nerve stimulation (10 pulse/sec) of a 3.0 kg male cat. Lower section: Epinephrine injection into femoral vein of a 2.8 kg male cat.

ZOLA P. HOROVITZ
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6. A description of the use of this technique for the study of drug actions on the reticular activating system is in preparation. The authors wish to thank Peter L. Carlton and Bradford N. Craver for the many helpful suggestions which aided the preparation of this technique and report.

5 July 1960

Letters

Science and Human Welfare

The statement of the AAAS Committee on Science in the Promotion of Human Welfare [*Science* **132**, 68 (8 July 1960)] is an admirable delineation of the crisis facing the scientific community in its relation with the general public. Mutual misunderstanding and lack of trust detrimental to both science and the people has evidently reached a level which makes remedial action rather urgent. Undoubtedly, both parties were at fault in creating this situation. Yet, subjected to severe pressure from the immense power generated by the scientist's discoveries, the public could hardly be blamed for considering irresponsible his disclaimer of any special competence for making decisions on the use of this power. Nor could the scientist help judging the public immature when its decisions on complex scientific matters were often based on partial or unproved information.

To remedy this schism the AAAS committee urges scientists and scientific organizations, as producers and custodians of scientific knowledge, to assume the obligation of imparting such knowledge to the public. Unquestionably, the committee understands that such a policy may involve these organizations in rather violent controversy, when some powerful political leaders with vested interests in particular governmental agencies are especially desirous of keeping certain facts from the public. Such politicians do not always conduct these controversies in accordance with the scientific principles of intellectual honesty, scrupulous integrity, objective and free speculation, and open communication. On the contrary, the usual process involves manipulation of public opinion by innuendo, half-truth and outright distortion of fact. Confronted by these conditions, the large scientific societies, in the past, found it safer to avoid entering public discussion on controversial matters. Fortunately, it is now recognized that this avoidance reaction was an abdication of social responsibility.

The AAAS could advance the objectives of its own committee by taking a vigorous position on such a scientific issue now before the public: Senator Dodd's demand, under threat of a contempt citation, that Linus Pauling hand over the names of all scientists who helped gather petitions against atom-bomb tests. The senator may be acting on behalf of men in the United States Congress who were annoyed by Pauling's success in disseminating widely the dangers of continued testing and by his effectiveness in raising the question of banning such tests to a public issue of widespread concern. Furthermore, these legislators seem determined to make any future action of this type as difficult as possible by generating the fear, particularly among young scientists, that participation on the wrong side of these controversial issues may place one's career and livelihood in jeopardy.

Since unhampered speculation and open communication are at the very foundation of the scientific tradition, the AAAS—as spokesman for the scientific community—should protest vigorously against the harassment of Linus Pauling by the committee of the Senate and the hunting down of dissident opinion by committees from both houses of Congress. For it is becoming more and more apparent that the atmosphere generated in this country by the activities of these committees has not only hampered the nation's scientific advances but has also sapped its democratic vitality.

BENJAMIN DE LEON
192 Keer Avenue, Newark, New Jersey

Small High Schools

In a letter to the editor [*Science* **131**, 1560 (1960)] Barker makes the point that small high schools "produced their full quota of scientists in 1957 and 1958." If all other variables are controlled, which is unlikely, the implied argument is that since it turns out its quota of scientists, the small high school is an adequate educational institution. This argument defends the small high school on the basis of the record of a small proportion of its graduates, potential scientists. It is quite possible that it does not make too much difference whether a high school is small or large as far as disciplines heavily dependent on the traditional academic curriculum and on high intellectual ability are concerned. Bright youngsters may learn mathematics, science, English, and the like in a high school of any size, provided instruction and facilities are fairly adequate.

But Barker's implied argument ignores the large mass of children who are of average and less than average intelligence. It is these children (as well as, perhaps, the more gifted children) that the small high school may not be serving adequately. The modern high school needs a variety of courses and activities —courses in languages, typing, home economics, citizenship, and elementary probability and statistics, extracurricular activities, and the like—which a small high school usually cannot offer. To a relatively gifted youth who is going to

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Program Content

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2. The "Challenge to Science" evening with Sir Charles P. Snow, Theodore M. Hesburgh, and W. O. Baker; Warren Weaver, presiding.
3. On "AAAS Day," the three broad, interdisciplinary symposia—Plasma: Fourth State of Matter; Life under Extreme Conditions; and Urban Renewal and Development, arranged by AAAS Sections jointly.
4. The Special Sessions: AAAS Presidential Address and Reception; Joint Address of Sigma Xi and Phi Beta Kappa by Polykarp Kusch; the Tau Beta Pi Address; National Geographic Society Illustrated Lecture; and the first George Sarton Memorial Address by René Dubos.
5. The programs of all 18 AAAS Sections (specialized symposia and contributed papers).
6. The programs of the national meetings of the American Astronomical Society, American Nature Study Society, American Society of Zoologists, History of Science Society, National Association of Biology Teachers, Scientific Research Society of America, Sigma Delta Epsilon, Society for General Systems Research, Society for the Study of Evolution, Society for the History of Technology, Society of Systematic Zoology, and the Society of the Sigma Xi.
7. The multi-sessioned special programs of the American Association of Clinical Chemists, American Astronautical Society, American Geophysical Union, American Physiological Society, American Psychiatric Association, American Society of Criminology, Association of American Geographers, Ecological Society of America, Mycological Society of America, National Science Teachers Association, New York Academy of Sciences—and still others, a total of some 90 participating organizations.
8. The four-session program of the Conference on Scientific Communication: The Sciences in Communist China, cosponsored by the AAAS, NSF, and ten societies.
9. The sessions of the Academy Conference, the Conference on Scientific Manpower, and the conference of the American Council on Women in Science.
10. The sessions of the AAAS Cooperative Committee on the Teaching of Science and Mathematics, and of the AAAS Committee on Science in the Promotion of Human Welfare.
11. Titles of the latest foreign and domestic scientific films to be shown in the AAAS Science Theatre.
12. Exhibitors in the 1960 Annual Exposition of Science and Industry—103 booths—and descriptions of their exhibits.

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specialize in science, the lack of such educational and social experiences, while regrettable, may not be very serious. But to a less gifted youth, and especially to a youth for whom high school is the limit of his formal education, the poverty of curriculum of the small high school is probably serious.

Like Barker, I would like data on how students from small and large high schools turn out. But I suspect that adequate data will be very hard to come by, due to the great difficulty of controlling independent variables in educational research of this kind. (An example of one of the most serious difficulties is the factor of individual selection: the bright child may be selecting the small high school, the private school, and the small college.) At any rate, of all citizens, scientists should be circumspect in their judgments and pronouncements on the relative merits of different types of education and educational institutions.

FRED N. KERLINGER
School of Education,
New York University, New York

Ancient Tobacco Smokers

The persistence of alkaloids in plant tissue 1300 years old has been reported by Raffauf and Morris [*Science* **131**, 1047 (1960)]. They reported a test for alkaloids but did not identify the substance present in tobacco samples. These samples were obtained from Indian caves in northern Arizona.

We have examined samples from the same archeological excavations (*1*). Microscopic and chemical investigations have shown that tobacco, presumably *Nicotiana attenuata*, was smoked by the Indians in pipes. Chromatographic and spectrophotometric analyses have established that nicotine was present in both loose tobacco and pipe dottel. The persistence of an alkaloid over such a period of time is remarkable, as Raffauf and Morris stated.

We believe our data are the oldest documented evidence for the smoking of tobacco (approximately A.D. 650) (*2*).

FORREST L. GAGER, JR.
VIRGINIA JOHNSON
JOSEPH C. HOLMES
McComas Research Center,
Philip Morris, Incorporated,
Richmond, Virginia

References and Notes

1. The samples were kindly submitted by Dr. Morris.
2. V. Johnson, J. C. Holmes, F. L. Gager, Jr., "A study of the history of the use of tobacco," paper presented at the 13th Tobacco Chemists' Research Conference, Lexington, Ky., 30 Oct. 1959.

Meetings

British Association for the Advancement of Science

The British Association was founded in 1831 "to convince an indifferent public and government that science is important and worth backing." Currently its main task is "the promotion of a better understanding of the significance for industry of scientific research and its impact, through its applications, of science as a whole." The annual meeting of the British Association is arranged accordingly in such a way as to present summary reviews and discussions of recent scientific advances for the benefit of a general public audience, with special sessions for young people. The annual meetings are held early in the fall, at cities around Great Britain, so as to bring scientists directly to local communities. The Cardiff meeting was a huge success in these respects.

Cardiff is a bustling city of nearly 300,000 and is now the capital of the principality of Wales. It has changed from a major coal exporting port to a general industrial center with many large parks and handsome public buildings. The great castle goes back to Roman times, but is chiefly a Norman structure, and the city has developed around it. Nearby is a large park containing the major public buildings, including the fine Welsh National Museum, the great City Hall, and the main university buildings.

Addresses

Some 4000 attended the 1960 meeting, under the presidency of Sir George Thomson, whose presidential address dealt with "Two aspects of science" (see page 996). This address was given at a formal occasion with full academic regalia. Sir George discussed the relations of pure and applied science. Honorary degrees were conferred by the University of Wales on Sir George Thomson, Sir James Gray (immediate past president), Dame Cathleen Lonsdale of the University of London, and on Principal W. Arthur Lewis of the University College of the West Indies.

Special evening discourses were given on "The structure of the universe" by Professor H. Bondi of the University of London, and on "Microbiological methods in the development of drugs" by Dr. E. V. Chain, professor of biochemistry of the Istituto Superiore di Sanita, Rome.

Outstanding were the addresses by presidents of sections: Dr. James Taylor on "Chemistry in industry"; G. S. Carter, "Tropical climates and biology"; Sir Alfred Pugsley, "Statics and the engineer"; Professor E. E. Evans, "The Peasant and the past"; Professor T. M. Harris, "The origin of angiosperms"; Dr. William Davies, "Pastoral systems in relation to world food supplies"; T. R. Peace, "The dangerous concept of the natural forest"; A. B. Oldfield-Davies, "Science broadcasting"; Dr. R. Woolley, "Stellar motions"; Professor E. B. Bowen, "Welsh emigration overseas"; Professor R. S. Sayers, "Monetary policy in Great Britain"; Professor William Burns, "The physiology of hearing"; Professor H. C. Dent, "Sixty years of progress in English education"; Professor R. C. Oldfield, "Experiment in psychology—a centenary"; G. F. Mitchell, "Pleistocene history of the Irish Sea"; and Professor D. V. Glass, "Population growth, fertility, and problems of policy."

Individual reports were arranged under the headings of the physical sciences; the biological sciences; forestry and agriculture; geography, anthropology and archeology; and economics, education, psychology and sociology.

Major interest at the meeting centered in the special symposium on world food and population. There were seven speakers in the symposium, and the general consensus was that technological improvements in the use of arable land can maintain adequate food supplies if population growth can be reasonably controlled.

Dr. Michael P. Reece of the Electrical Research Association gave the Kelvin lecture on "Physical principles of switches and circuit breakers." The Lister lecture was given by W. M. Williams of the University College of North Staffordshire on the "Social study of family farming." Interesting was the Darwin lecture by Martin J. Wells of Cambridge University on "What the octopus makes of it: Our world from another point of view."

For the young people there were special panel discussions on questions submitted by students, and there was an excellent exhibit on science teaching in schools. The York lecture for young people was given by Sir James Gray on "The flight of birds." Professor A. Charlesby talked on "Atomic radiation and materials." B. B. Lloyd discussed "Ends and means in human respiration," and Professor C. E. H. Bawn lectured on "Plastics and fibers." Scientific films were also shown, and special exhibits were arranged in the National Museum of Wales. Sectional excursions were provided for geologists and other groups.

Outstanding at the meetings of the British Association for the Advancement of Science are the social functions. The city of Cardiff and the University College were lavish in their entertainment. There were receptions, luncheons, and dinners, arranged with delightful formality and with a minimum of speaking. The Lord Mayor (Mrs. Dorothy Lewis) and the corporation of Cardiff gave a civic luncheon, as well as a general reception.

Sir Wilfred Le Gros Clark, professor of anatomy at Oxford University, succeeds Sir George Thomson, professor of physical chemistry at Cambridge University, as president of the British Association. Sir Wilfred is widely known for his studies on nerve regeneration and on paleontology. In thanking Sir George Thomson for his presidential address on the undertsanding and control of nature, Sir James Gray, past president, referred to the unique situation of son following father in the presidency of the British Association. Sir George's father was the famed J. J. Thomson, whose concept of electrons opened the atomic age. Both father and son were Nobel laureates.

With full and detailed press coverage, the Cardiff meeting of the British Association was especially successful with respect to its prime function of promoting a better understanding of the significance of scientific research. The program was well arranged. The various papers and symposia will be published in *The Advancement of Science*, the well-designed periodical maintained by the BAAS.

The AAAS was represented officially by Dr. Alfred S. Romer of the Board of Directors and by the President. Dr. Carl F. Kayan of the Council was a guest of the Engineering Section. Several other Americans attended the meetings. All were impressed by the pleasant character of the occasion, the delightful hospitality, and the high quality of the scientific discussion.

CHAUNCEY D. LEAKE

President, AAAS

Forthcoming Events

November

2–4. Plasma Physics. 2nd annual, Gatlinburg, Tenn. (A. H. Snell, Oak Ridge Natl. Lab., Oak Ridge, Tenn.)

2–4. Society for Experimental Stress Analysis, Berkeley, Calif. (W. W. Murray, Massachusetts Inst. of Technology, Cambridge)

2–5. American Soc. of Parasitologists, Los Angeles, Calif. (F. J. Kruidenier, Zoology Dept., Univ. of Illinois, Urbana)

2–5. American Soc. of Tropical Medicine and Hygiene, Los Angeles, Calif. (R. B. Hill, 3573 St. Gaudens Rd., Miami 33, Fla.)

2-5. American Speech and Hearing Assoc., Los Angeles, Calif. (K. O. Johnson, 1001 Connecticut Ave., NW, Washington 6)

3–4. Electrostatic Propulsion, conf., Monterey, Calif. (J. M. Sellen, Thompson Ramo-Wooldridge, Inc., 8433 Fallbrook Ave., Canoga Park, Calif.)

3–4. Muscle as a Tissue, conf., Philadelphia, Pa. (Division of Research, Lankenau Hospital, Philadelphia 31)

4–5. West-Central States Biochemical Conf., Lincoln, Neb. (J. H. Pazur, Dept. of Biochemistry and Nutrition, Univ. of Nebraska, Lincoln)

4–6. Assoc. of Clinical Scientists, Washington, D.C. (R. P. MacFate, 54 W. Hubbard St., Chicago 10, Ill.)

5. Society for Industrial and Applied Mathematics, Philadelphia, Pa. (G. Kaskey, Remington Rand Univac, 1900 W. Allegheny Ave., Philadelphia)

7–10. Society of Exploration Geophysicists, 30th annual intern., Galveston, Tex. (C. C. Campbell, Box 1536, Tulsa, Okla.)

8–10. Forensic Sciences, 2nd symp., Washington, D.C. (Director, Armed Forces Inst. of Pathology, Washington 25)

9–10. Use of Secondary Surfaces for Heat Transfer with Clean Gases, symp., London, England. (Secretary, Institution of Mechanical Engineers, 1 Birdcage Walk, London, S.W.1)

9–11. Clinical Chemistry Methods, symp., Cleveland, Ohio. (A. Hainline, Cleveland Clinic, 2020 E. 93 St., Cleveland 6)

10–12. Geological Soc. of America, 73rd conv., Denver, Colo. (H. R. Aldrich, GSA, 419 W. 117 St., New York 27)

10–12. National Assoc. of Geology Teachers, Denver, Colo. (F. Foote, Dept. of Geology, Williams College, Williamstown, Mass.)

10–13. Pacific Coast Fertility Soc., Las Vegas, Nev. (A. C. Wineberg, 3120 Webster St., Oakland, Calif.)

11–12. Paleontological Soc., Denver, Colo. (H. B. Whittington, Harvard Univ., Cambridge 38, Mass.)

13–16. Society of American Foresters, 60th annual, Washington, D.C. (H. Clapper, SAF, 825 Mills Bldg., Washington 6)

14–17. Magnetism and Magnetic Materials, 6th annual conf., New York, N.Y. (L. R. Bickford, Jr., I.B.M. Research Center, Yorktown Heights, N.Y.)

14–18. American Soc. of Agronomy, Chicago, Ill. (L. G. Monthey, 2702 Monroe St., Madison 5, Wis.)

14–18. Nuclear Ship Propulsion, symp., Taormina, Sicily. (International Atomic Energy Agency, 11 Kärntner Ring, Vienna 1, Austria)

15–16. Engineering Application of Probability and Random Function Theory, symp., Lafayette, Ind. (J. L. Bogdanoff, School of Aeronautical and Engineering Sciences, Purdue Univ., Lafayette)

16–19. Society of Naval Architects and Marine Engineers, annual, New York, N.Y. (W. N. Landers, SNAME, 74 Trinity Pl., New York 6)

17–19. Extrapyramidal System and Neuroleptics, intern. symp., Montreal, Canada. (J.-M. Bordeleau, Dept. of Psychiatry, Univ. of Montreal, Montreal)

17–19. Surgery of Endocrine Organs, symp., New York, N.Y. (Office of the Associate Dean, New York Univ. Post-Graduate Medical School, 550 First Ave., New York 16)

17–20. American Anthropological Assoc., Minneapolis, Minn. (B. J. Meggers, 1530 P St., NW, Washington 5)

17–20. Southern Thoracic Surgical Assoc., Nassau, Bahamas. (H. H. Seiler, 517 Bayshore Blvd., Tampa 6, Fla.)

(See issue of 16 September for comprehensive list.)

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(a) **Organic Chemistry** Ph.D., extensive research and supervisory experience with pharmaceutical firm on metabolism and atherosclerosis studies and new product development; available for research and administrative appointment with drug firm. (b) **Plant Physiology** Ph.D., with radiochemistry and nuclear physics training; 8 years of university teaching in agronomy; prefers teaching or research. S10-2 Medical Bureau, Inc., Science Division, Burneice Larson, Chairman, 900 North Michigan Avenue, Chicago. X

POSITIONS WANTED

Clinical Laboratory, 57; M.D. licensed in Ohio, citizen. Broad laboratory experience. Especially hematology (bone marrow), bacteriology, serology, blood bank, and minor biochemistry. Wishes for chief of clinical laboratory, excellent references. Write to Box 192, SCIENCE. X

POSITIONS OPEN

BIOCHEMIST OR BIOPHYSICIST

Ph.D. Research on the composition, conformation, heterogeneity, and metabolism of nucleic acids. Salary: Commensurate with experience. Send résumé to Dr. Saul Kit, Head, Section of Nucleoprotein Metabolism, The University of Texas, M.D. Anderson Hospital and Tumor Institute, Houston, Texas. 10/21

BIOCHEMIST to conduct independent programs of isolation and identification of small molecule intermediates and cofactors of mitochondrial oxidative phosphorylation. Originality and creativity desirable. To associate with protein chemist and physical chemist in primarily basic biochemistry group. Modern equipment including automatic chromatography, electrophoresis, and radioactivity laboratory is provided. Adequate research funds available. Box 188, SCIENCE.

CHEMIST

Experienced in drug analyses. Able to apply modern physical methods. Willing to work at bench and assume supervision of others. Long-established independent laboratory, central Philadelphia. State training and experience. Immediate opening, starting date may be as late as 1 November. Replies confidential until after personal interview.

Box 179, SCIENCE

POSITIONS OPEN

(a) **Director, Clinical Research.** M.D. experienced clinical pharmaceutical research for midwestern division, prominent pharmaceutical company; to $20,000. (b) **Assistant Medical Director(s);** young M.D.'s, preferably some pharmaceutical experience, able initiate independent action, good critical judgment; eastern laboratories; to $18,000. Science Division, Woodward Medical Bureau, Ann Woodward, Director, 185 North Wabash, Chicago. X

IMMUNOLOGIST

Male/female, M.S., or recent Ph.D. Background in tissue culture; genetics desirable. Send résumé.

Dr. H. Gordon
St. Barnabas Medical Center
High St., Newark, N.J.

IMMUNOLOGIST

To participate in research involving pituitary antihormones. Familiarity with agar-gel diffusion and immunoelectrophoresis techniques desirable but not essential. Academic institution, New York City. Salary and academic status open.

Box 190, SCIENCE

MEDICAL TECHNICIAN

Male/female, B.S. preferred, research laboratory, paraffin sectioning, H and E plus special staining. Some experience required.

Dr. H. Gordon
St. Barnabas Medical Center
High St., Newark, N.J.

POSITIONS OPEN

Biochemist, Ph.D. Position available for Ph.D. biochemist as Division Chief of Toxicology in commercial clinical and industrial analytical laboratory in southern California. Must have had some experience in analytical methods for routine toxicological laboratory (Pb, As, barbiturates, and so forth). Position involves supervision of technicians for routine tests, some contact work with industry, research in methodology (research technician available), and liaison with other analytical sections of the laboratory. Salary open. Please submit résumé with photo, stating salary requirements. Box 193, SCIENCE. 10/21

LITERATURE SCIENTISTS

To evaluate, abstract, and index scientific information and to prepare literature surveys. Opportunity to participate in further improvement and expansion of information retrieval activities. Training in chemistry or biomedical sciences, with writing and foreign language skills. Interest and/or experience in mechanized information retrieval desirable.

These positions are in an expanding science information group and offer excellent working conditions, employee benefits, and growth opportunities.

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Pharmaceutical Chemist. Two men with Ph.D. degrees or equivalent training (with or without industrial experience) required in the Pharmaceutical Product Development Department of a large ethical pharmaceutical company in upstate New York. Both positions involve research on pharmaceutical dosage forms. One man should also have a fairly strong background in organic chemistry. Work requires creativity and imagination. Excellent starting salaries and fringe benefits. Expansion of the company presents opportunities for advancement. Box 187, SCIENCE. 10/14, 21, 28

(a) **Research Biologist and Geneticist** for new fishery research station; Southwest. (b) **Clinical Scientist** qualified in hematology, blood banking, and immunology for 300-bed university-affiliated hospital; high salary; Texas. (c) **Marketing Consultant** for pharmaceutical division of internationally known research firm; qualified in long-range planning and merchandising with growth potential; $15,000–$18,000; East. (d) **Virologist** for independent preventive medicine research with some teaching at university medical school; to $10,000; South. (e) **Geneticist** for cancer research at leading medical institute; East. (f) **Biochemist** to take charge of department in expanding hospital; up to $12,000; Midwest. (g) **Physiologist** for burn and hemorrhagic shock research qualified to organize and direct program; over $10,000; South. (h) **Microbiologist** to be groomed as director of division in health department and develop research in chronic disease field; $7000–$10,000; increase to $12,000; Midwest. (i) **Electron Microscopist** to study cytology of neoplastic diseases and take charge of new department at research institute; Midwest. S10-2 Medical Bureau, Inc., Science Division, Burneice Larson, Chairman, 900 North Michigan Avenue, Chicago. X

RESEARCH CHEMISTS

The following positions are open in expanding Research Division of pharmaceutical company located in Philadelphia. Salary commensurate with training and experience.

Synthetic Organic Chemist, Ph.D. with 3-5 years experience in heterocyclics of drug design.

Microbiologist, Ph.D. or equivalent, with 3-4 years experience in virology, tissue culture, and bacteriology.

Analytical Chemist, Ph.D. or equivalent with experience in microanalytical and spectrophotometric procedures in organic chemistry.

Reply giving complete information and salary requirements. Box 194, SCIENCE.

POSITIONS OPEN

PHYSICISTS

LOS ALAMOS SCIENTIFIC LABORATORY, operated by the University of California and located in the mountains of Northern New Mexico, invites applications from Ph.D. physicists with experience or a strong interest in atomic and molecular physics, electronic and ionic collision processes, physics of ionized and hot gases, or upper atmosphere physics. The programs are of a fundamental theoretical and experimental nature, and are related to advanced phases of LASL programmatic problems. The stimulating academic atmosphere and availability of modern facilities and elaborate instrumentation make employment at Los Alamos attractive and rewarding. Please send résumé to Recruiting Department

LOS ALAMOS SCIENTIFIC LABORATORY
University of California
Los Alamos, New Mexico

RESEARCH ASSISTANT, B.S. or higher. Conscientious person with good college record in chemistry and willingness to learn. Desired for work on the central nervous system employing biochemical and biophysical techniques. Salary consistent with training and experience. Midwestern university.

Box 184, SCIENCE

RESEARCH MICROBIOLOGIST

Ph.D. (under 35) or equivalent experience. Interest in **IMMUNOLOGY, VIROLOGY,** or **TISSUE CULTURE** desirable but not necessary.

Opportunity with an excellent future in an expanding program in vaccines and chemotherapy with an ethical manufacturer of pharmaceuticals and biologicals.

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2538 S. E. 43rd Street
Des Moines, Iowa

TECHNICAL ASSISTANT

To work on protein synthesis in bacteria, at Johns Hopkins University.

Experience in biochemical and radiochemical techniques is desirable. Salary $5500. Position open immediately. Send résumé to

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